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Monitoring plant phenology between citizens and science: “Serralves em Flora”, a case study from Portugal

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O Presidente do Júri,

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Abstract

Climate change has been a common research and discussion topic during the last years due to the temperature changes registered across the globe. Although some of the consequences of this phenomenon are known, as the ice melting in the Polar Regions, other consequences are unknown to the public, even if they are taking place in the regions where human populations live. Flora life cycles have been changing over time due to climate change but human populations that directly or indirectly interact with plants do not always realize it. To foster public awareness and motivation, phenology programs based on citizen science have been developed in several areas of the globe allowing citizens and scientists to participate in monitoring networks for the study of climate change.

Phenology monitoring programs allow citizens to collect flora phenology data, while participating on scientific studies on climate change. As the amount of data gathered by citizens increases, more information becomes available to scientists and more accurate predictions can be made for the changes in flora phenology.

For this work, information on the citizen science phenological programs currently available was gathered, analysed and used to support the designing of a citizen science phenological project called “Serralves em Flora”, for Serralves Park, a private historic garden for public use, located in Oporto, Portugal. Therefore, the methodology used for the creation of this project was based on other existing programs and aggregated in 9 methodological steps that are crucial for the designing and development of a plant phenology monitoring program. It is expected that, with the help of volunteers in the data collection along the years, the study of the effect of climate change on Serralves Park flora becomes possible and sustainable.

Key words: climate change, phenophases, citizen science, methodological steps, monitoring networks

Resumo

As mudanças climáticas têm sido um tópico comum de investigação e discussão durante os últimos anos devido às mudanças de temperatura por todo o mundo. Apesar de algumas das consequências destas alterações serem conhecidas, como o degelo nas regiões polares, há ainda consequências que, mesmo que ocorram nas proximidades das populações, são desconhecidas. Os ciclos de vida de muitas espécies de flora têm vindo a alterar-se ao longo do tempo devido às mudanças climáticas, mas os cidadãos que interagem direta ou indiretamente com as plantas nem sempre se apercebem disso. Para a sensibilização e motivação do público, os programas fenológicos baseados em ciência feita pelo cidadão (*citizen science*) têm sido desenvolvidos em diversas áreas do globo, o que permite aos cidadãos e cientistas participarem em redes de monitorização para o estudo das alterações climáticas.

Os programas de monitorização fenológica permitem que os cidadãos obtenham dados fenológicos da flora, participando deste modo em estudos científicos sobre as alterações climáticas. Quantos mais dados forem obtidos, mais informação pode ser utilizada pelos cientistas e mais precisas serão as previsões feitas para as mudanças da fenologia da flora.

Para este trabalho, foi recolhida, analisada e utilizada a informação sobre programas fenológicos com ciência do cidadão para suportar a conceção de um projeto fenológico de ciência feita pelo cidadão chamado “Serralves em Flora”, para o Parque de Serralves, um jardim histórico privado de utilização pública, localizado na cidade do Porto, Portugal. A metodologia utilizada para a criação deste projeto foi baseada noutros programas existentes, agregada em 9 passos metodológicos que são cruciais para a conceção e desenvolvimento de um programa de monitorização fenológica de plantas. Espera-se que, com a ajuda de voluntários na recolha de dados ao longo dos anos, o estudo do efeito das alterações climáticas ao nível da fenologia da flora do Parque de Serralves se torne possível e sustentável.

Palavras-chave: alterações climáticas, fenofases, ciência cidadã, metodologia, redes de monitorização.

Table of figures

Table index

I. Introduction

1. Phenology

Phenology is the science that studies cyclic events of the life cycle of different living beings, which are called phenophases [1 - 4]. The methods to study phenophases usually include registration of the dates when these occur. After collecting systematic data over the years, it becomes possible to study the phenology of that organism [5 - 14].

Phenophases are different from one type of organism to another. For example, for animals, phenophases consist in migration or reproduction events, while in plants, phenophases are focused on the leaves, flowers and fruits development. In this work, the phenology study is dedicated to plant development [5 – 8, 15, 16].

The actual and scientific reason behind the importance of phenology studies is the monitoring of climate change phenomena. A phenologic change has been occurring over the years along with the climatic change, which has brought some changes to the world, like the temperature variation over the different seasons. These changes affect the phenophases of the organisms, more precisely the dates when they occur. It may not look important, but a more careful look over it shows an eventual problematic situation on the future ecosystem balance [1 - 4, 6 – 14, 17 - 20].

Climate change causes an adaptation of the species to the new environmental conditions. There can be two types of adjustments: i) long term, which affects the future generation of the species that were affected by the climate change, and ii) short term, which affects the life time of the organism. This new adaptation can create a conflict with another species that is linked to the first one, causing the second one to suffer from the change and, eventually, disappear. The disappearance of the second species destroys the balance between them, damaging the first species, which can also lead to its extinction. To prove this catastrophic reaction some studies and experiments were made with different linked organisms, like plants and their pollinators [20].

An example of the cascade of consequences of the changes on the phenophases, is the one causing consequences on plant-pollinator network, leading to great losses on both sides due to mismatches of both species populations [20]. On a higher scale, climate change can even affect biome integrity, so it is important to be able to predict

such scenarios in time, when there is still a chance to do something to prevent or adapt [20]. One way to predict these type of scenarios is through phenology studies.

2. Plant Phenology Monitoring

2.1. Concepts and methods

Nowadays, with all the technology available, plant phenology monitoring evolved exponentially, from registers in a sheet of paper to sophisticated satellites datasets. With the evolution of monitoring techniques and formats, data collection became faster, easier to get and a precious study material for scientific reports [9 – 15, 21, 22].

The most simple and common technique to collect phenology data is the **direct observation and annotation**. This technique is commonly used by volunteers and scientists *in situ*. It uses an observation sheet specifically created by phenological monitoring programs, for one or several species, usually available on a website/platform. This method, despite being the most common and most used on a global level, also requires a specific amount of work and dedication. The registration must be regular, so that the date of the phenophase is not missed, and precise, so that the data collected possesses the necessary quality required to be used in scientific studies [2, 4, 6 – 15, 17].

The **digital repeat photography** method requires less people, but more sophisticated equipment. It uses repeat photography to monitor phenophases. The digital camera is placed on a strategic position pointed to the species of interest, so that the camera angle can capture the tree on a good perspective in every weather condition. This technique is more accurate than the first one, since photography allows a person to review the data exactly as it was collected as many times as needed and can be manipulated mathematically to improve, detect patterns and classify objects [22].

One of the most recent methods for phenology monitoring is **satellite phenology observation**. It uses satellites to capture vegetation phenology, but, when the other two methods focus on a species at a time, this one can capture information of all the plant species of a local or even global area. Despite the large data collection, using only a satellite to gather data can create complications once the data starts to be analysed. Having such a big distance from the study area, there can be some interferences on the received information, since the vast density of vegetation might not

allow a consisted and detailed observation on the local area. A possible solution for this problem might reside in the knowledge of the local area, where the data collected previously could be compared with the new one collected with the satellite. [21, 23].

Regardless of which method is used to monitor vegetal phenology, all will gather and store data. The following question is how to transfer these collected sets of data to scientists and to analysis procedures. The solution consists on the creation of networks.

2.2. Monitoring Networks

Monitoring Networks are phenology monitoring projects that exist all over the world and can be accessed online, usually through a website. They were created to study climate change on a global level using a phenological study made in the countries in which the networks are located. These networks allow input and output of phenological data. In this way, volunteers and scientists with data or that are interested in existing databases collected by others, can download the network data (already treated or in the original state). [2, 21].

Currently, there are different networks worldwide, some more complex or comprehensive than others. From all projects found during the research for this work (Appendix I), the best-known and most referenced were [2, 21]:

- PlantWatch (Canada);
- National Phenology Network or NPN (USA);
- European Phenology Network or EPN (Europe);
- Phenology Eyes Network or PEN (Japan);
- Phenology Network – Nature’s Calendar (UK).

PlantWatch is a part of a Canada national nature watch series of volunteer monitoring programs, designed to study native plants of Canada [11, 21].

NPN network involves botanical gardens, government agencies and universities on the phenological data collection and analysis. It possesses 2000 field study sites across the USA [14, 21].

EPN and PEN networks are very similar. The EPN involves several universities and research centres on the phenological study all over Europe. The PEN involves the same typology of partners as the EPN, with the difference that these partners are from

Japan. The other difference is that the PEN network studies phenology through satellites, analysing plants from other regions beside Japan, although the majority is located there [13, 21, 24].

The UK Phenology Network focuses its phenological studies in spring and autumn, for both plants and animals. It involves the Royal Meteorological Society, along with universities from the UK to collect and analyse the phenological data from UK native species [10].

3. Citizen Science

3.1. Global Citizen Science Networks

Citizen science can frequently be seen as a partnership between citizens and scientists, where typically the first collect data through phenological monitoring procedures and the second use that data for scientific studies (usually studies about climate change) [25 - 28].

This partnership is linked to programs, more precisely, citizen science programs, some connected to the monitoring networks previously mentioned. These programs are created with the intention of creating a bigger contact between the public, environment and science. With this link of people and science made by phenological monitoring, it is possible to enhance the amount of registered data of different geographical regions available to scientists that would be difficult to get otherwise [25, 26]. Additionally, the data gathering and analysis becomes faster because of the large group of volunteers involved. Without these, the programs would not have the necessary funds to recruit technicians in such a large number for data collection. Although the success and sustainability of this public involvement has not been proved so far, one of the goals of this type of citizen science projects is to raise awareness and engage citizens in the issue of climate change caused by anthropogenic influence [25 - 28].

On the other hand, the achievement of global scale monitoring is possible since, in order to obtain data from different regions of the world, volunteers gather the data in different regions and place it in a database that can be accessed by everyone [2]. To make this process easier, partnerships can be made between programs, creating networks that allow all the data from the linked programs to be stored and treated together. Each program will associate their data to its own database, for their volunteers to access it, but share it in the network. The partnership network combines

different databases, treats data and creates phenology monitoring results on a global scale. This way, scientists can use this information to study the global variation of phenology more quickly and efficiently [2].

3.2. Methodological steps of citizen science phenological monitoring programs

Several citizen science monitoring programs of phenology currently exist in different regions of the world and each contains its own method to collect data. Nevertheless, and although some criteria might differ between them, there are 9 crucial steps that are present in every phenological monitoring program [9 - 14]:

1) **Observation Methods** – it is important to consider a method of observation that can be reproduced in any study area selected by the volunteers. The materials needed for the selected method must be easy to obtain and to carry, but must be precise to record the phenological data [2, 4, 6 – 15, 19, 28].

2) **Monitoring Scale Selection** – since one of the objectives is to reproduce the phenological monitoring project in any type of study area, it is important to create a method that can be adapted to different types of areas, whether they are home gardens or city parks [2, 6 - 15, 29].

3) **Phenophase Selection** – this step must contain the most visible plant features for volunteers to collect accurate data, so it is vital that they can easily identify the occurring phase. For transversal comparison between phenological citizen science projects and databases, it is also important that widely used phenophases are selected [2 – 14, 29, 16, 30].

4) **Names of the Phenophases** – since the volunteers consist mainly of citizens possibly without academic botanical training, it is important to establish an accurate, yet simple, denomination for each phenophase. This way the volunteers will identify the phenophase in a more intuitive, correct and quick way [5 – 16, 28].

5) **Species Selection** – it is necessary to create specific criteria to allow a species to be selected for monitoring recording. This criteria must be transversal, which means, it can be applied to any plants species and allow the prioritization of monitoring targets [2 – 14, 29].

6) **Monitoring Sheets** – the record sheets must be easy to understand, to use and to carry. It is also important that the monitoring sheets are accessible to every citizen. These sheets must be established to be used in any study area, and for the selected types of plant species. They can be designed for a specific taxon, a group of taxa or, if adapted, to all the taxa included in the program [6 - 16, 31].

7) **Observation Frequency** – it is expected to record the variation of each phenophase along the years (due to biologic variation, ecologic disturbance, and climate change), so each population/study area needs to be assessed through time. This frequency can differ depending on the study area selected. Study areas selected by programs can lead to different observation frequencies than the ones made in the study areas selected by the volunteers, since it all depends on the distance that the volunteer must travel to the study area [7, 8, 15].

8) **Website** – it is important that the website is “user friendly” and it must contain a core information section about the species, the phenological monitoring rules and the corresponding monitoring sheet for volunteers to access it. It should also contain a monitoring guide for volunteers to follow in case of need, and the contacts of the responsible and sections to help volunteers in their questions [9 – 14, 26]. Volunteers can use the website to obtain the monitoring sheets, the information about the species included in the study and, in the case of city gardens or parks, to obtain information about monitoring events that may occur and in which they can participate [9 – 14, 26]. The website can also be used as a training tool, making available online videos of recorded training sessions in order to help online users [14].

9) **Data**:

   - **Documentation** – the website possesses a database created for the volunteers to store the data collected from their field observations. It is important that the database is “user friendly” to allow a correct data storage [2, 7, 9 – 14, 25, 26, 28].

   - **Quality Control** – for volunteers to be able to autonomously collect accurate data it is important to teach them the correct way to register data. The website should possess the required tools (field guides for phenology

monitoring and formation sessions dates), so that volunteers can easily access them [2, 7, 9 – 14, 25, 26, 28].

- **Process and Publication** – in order to use the recorded data in scientific works, it is necessary to treat the gathered phenological records to analyse phenological change over time for each species. After data is treated, it should be made available on the website to be download by anyone interested [2, 7, 9 – 14, 25, 26, 28].

3.3. Volunteers and training

Volunteers of monitoring programs usually consist of citizens that are interested in participating and learning new information about ecology. The programs do not establish age limits, welcoming every citizen and profile. Nevertheless, the most common is that schools and citizens with knowledge and experience in ecology studies or environmental actions become volunteers. Some may have studies on this area, but it is a premise that there are no requisites for the volunteer’s profile that can participate in these programs [9 – 14, 25, 26].

Accordingly, there are some basic training initiatives to improve data quality and reliability so that phenological records by volunteers can be used in scientific studies [6 - 9, 14, 26]. The training sessions (also called formation sessions) can be held by scientists or technicians of the study area and are intended to teach basic techniques and the steps that a volunteer should follow when collecting data. They typically have theoretic and practical components, and it is expected that, after this training, the volunteers can gather data by themselves, in any place, like a home garden or the street [14, 26].

Web platforms play an important role for citizen science involvement and training, since they can be viewed by anyone, anywhere and anytime. Guides about phenological monitoring with the same information that is lectured in the training sessions, and also monitoring sheets, that are used to write down the data collected by the volunteers are always made available in these websites along with information already collected for the monitored species. In this way, volunteers can study them and learn what they can expect to find in their observations [6 - 14, 26]. To compensate for the lack of a practical component training, volunteers can also access the website to watch video sessions filmed during the practical component of the training sessions [14]. Finally, websites also promote training by allowing volunteers to communicate

with the organizers of the program by mail or other contact platforms, to present encountered problems or their eventual doubts [9 - 14].

Although citizen science is progressively more used in monitoring programs, some problems associated with the methods and the phenology parameters to be assessed remain. Additionally, data viability is one of the biggest concerns since volunteers, despite the standardized training, show different inherent capacities that reflect on the quality and viability of recorded data [25, 26, 28].

Tests were made to determine the best way to give training to the volunteers and the results showed that the training sessions with technicians specialized on the area result in better learning and data quality in comparison with situations in which the volunteers are autodidacts, usually using only the website guides. On the other hand, other tests showed that if the information on the record sheets or platforms is too complex, long or repetitive, or if the necessary equipment is too elaborated, or even the method is too complex, volunteers’ participation can be compromised [25 - 28].

4. Aims and specific objectives

The world’s flora distribution and phenology is changing rapidly and with volunteer contribution, conservation assessments are possible [1 - 4, 17 - 20]. Over the years, the number of citizen science programs has widely expanded. Nowadays, there are programs that allow schools to participate in plant monitoring, so that the students may have an early contact with nature and change their way of perceiving it [8, 14].

This work pretends to create a specific citizen science program that allows people interested in this subject to study the phenological impact that climate change is causing on selected plants in their vicinities (woods, parks or even small house gardens). The data collected from different areas over the years will be used, if adequate, on scientific studies referring to the effects on flora from climate change, allowing the population to be more active and helpful on environmental issues.

Table 1 - Specific objectives of this work

Meta-analysis of existing citizen science monitoring programs	– Obtain information and data about existing programs worldwide; – Determine the common information used for the creation of citizen science programs; – Select the information of interest to use in our work.

Scientific citizen science project	– Develop a citizen science project with a strong scientific base; – Development of program characteristics adapted to different types of study areas; – Develop a user friendly program to use without the constant supervision of a technician.
“Serralves em Flora” citizen science project	– Create a methodology for a citizen science project adapted to Serralves Park; – Develop a set of criteria for plant species selection; – Develop user friendly monitoring sheets for the selected species; – Design a module for monitored flora of “Serralves em Flora” to be included on the existing citizen science website platform of Serralves Foundation. Create partnerships between “Serralves em Flora” and other national and international citizen science programs.

5. Study area characterization

5.1. Portuguese climate and vegetation

Portuguese territories present two types of climate: Mediterranean and Atlantic. The Mediterranean climate covers a large part of the country (almost 2/3) while the Atlantic only covers a small part [32, 33]. Mediterranean climate is defined as presenting some tropical characteristics, such as hot and dry summers and mild winters that sometimes are subjected to some disturbances that come from the west [32]. Atlantic climate, on the other hand, is controlled by ocean influence and the constant winds which determine climatic amplitude through the year. Temperature differences between summer and winter on zones under the influence of Atlantic climate are smaller than on Mediterranean climate zones thanks to this influence. Atlantic summers are fresher and more humid, and the winters are much colder and rainy, even snowy in the highlands [32].

There are specific flora species associated to each of these types of climate. Mediterranean flora usually consists of small, evergreen trees, with few herbaceous vegetation due to the extreme heat of the climate. This flora’s region adapted to dryness through some physical adaptations to reduce the amount of water lost by the plant, as the leaf and root sizes and trunks are covered with thick bark [32, 34]. Atlantic

flora is usually composed of large, deciduous trees, with more herbaceous vegetation than on Mediterranean areas. This region’s flora achieved adaptations to cold and wet climate through some adaptations, such as the fall of leaves, size of the leaves and trunk, and altitudinal distribution of their habitat [32, 34]

5.2. Serralves Park

Serralves Park, located in Oporto city (Portugal) is geographically placed on the transition climate zone between Atlantic and Mediterranean [33]. This transitional climate allows a wider diversity of flora on the parks and gardens located in this city, more precisely, the co-existence of plants from different Atlantic and Mediterranean climates in the same area [32, 33]. Serralves Park is a good example of this situation and was elected as the study area of this work.

With 18 hectares, Serralves Park is considered a fundamental ecological structure for Oporto city, revelling itself as an alive, dynamic and complex system. It is structured in three parts: a Museum (“Museu de Arte Contemporânea”), a House (“Casa de Serralves”) and a Garden (“Jardim de Serralves”) (Figure 1) [35 - 38].

Serralves Park contains 8.000 exemplars of woody plants: trees and shrubs, natives and exotics. There are some rare native species of Portugal in the park, such as the yew and some representing national flora, like the holly, laurel, chestnut and cork oak. The exotic vegetation includes some emblematic trees, like the giant sequoia, sweetgums, tulip trees, cedars and centennial plants, such as Japanese camellias. The flora is very important for the parks character, turning its landscape into a unique and sustainable place. For the fauna, Serralves contains a vast diversity of vertebrate and invertebrate animals. 98% of animal species are invertebrates and the remaining 2% are composed by 50 species of birds, 4 species of mammals, which are located on the Fields and represent endangered species of farms animals, 4 species of amphibians and 2 species of reptiles [37].

Before 1925, the Park existed as a romantic garden with the name of “Quinta do Lordelo” and it was smaller than nowadays. When the expansions started (between the 20’s and 40’s) the name changed to “Quinta de Serralves” (being concluded in 1940), changing later to “Parque de Serralves” when the Portuguese state bought it in 1987. Jacques Gréber was the responsible for the garden alteration starting in July 1932. Public visits started in 1987 and thanks to that, some recovery actions were taken to

adapt the existing space to the visitors. These actions were key to the transition from a private space to public space [37].

Serralves Park is divided in three zones: the upper zone, the transition zone and the lower zone (Appendix II) [35, 36, 38].

All trees and shrubs present in the park are identified and georeferenced on a platform, which is used for divulgation and management of the botanical heritage of the park. Taking advantage of this platform, and promoting the dissemination of this plant heritage, the development of a flora monitoring project is a great asset, and complements the fauna monitoring project already implemented by Serralves Foundation.

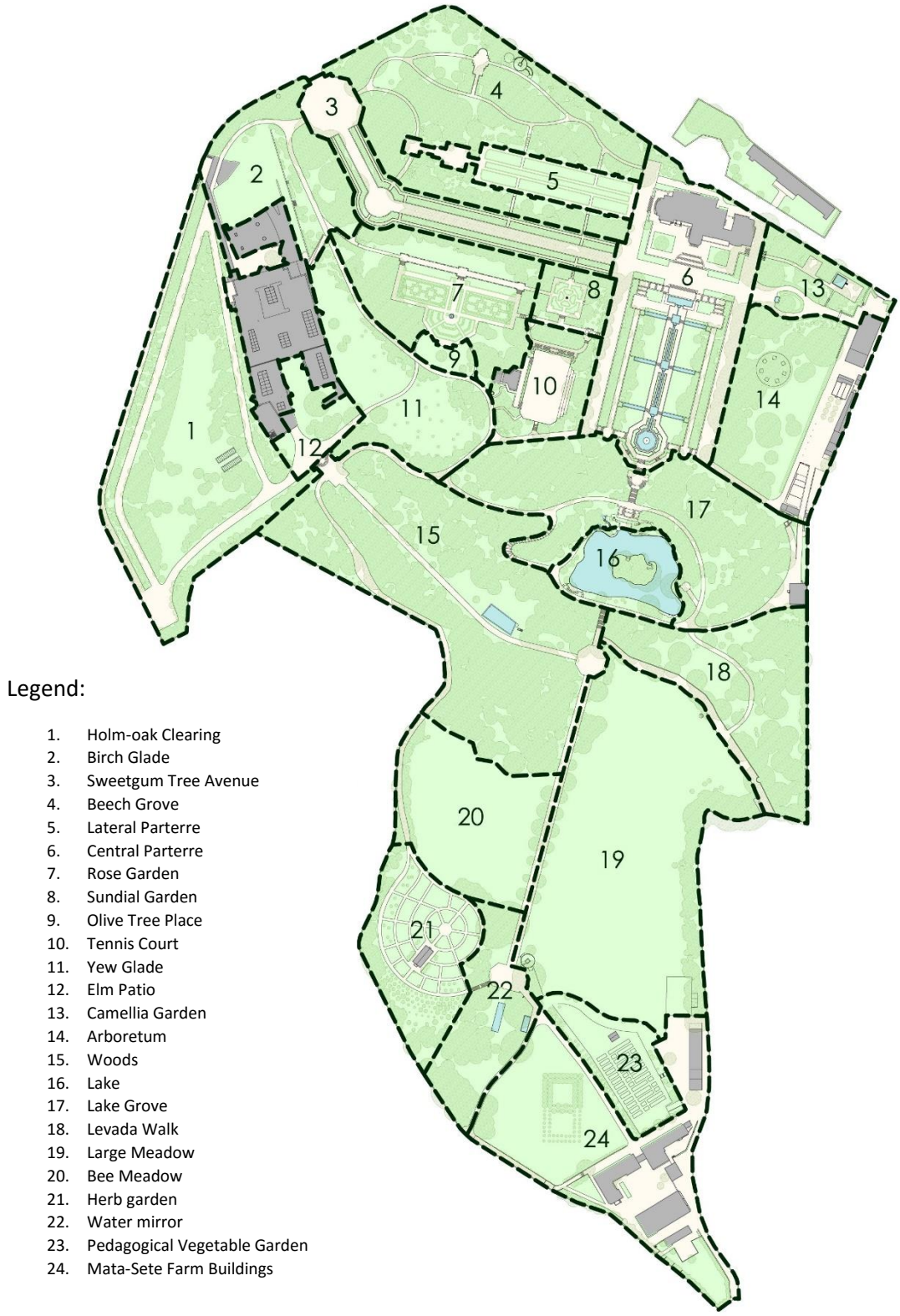

Figure 1 - Map of Serralves Park divided by sections with legend of the areas

II. Materials and Methods

1. Methodological meta-analysis of existing phenological monitoring programs

1.1. Background

Phenology monitoring has been practiced for some time now for science purposes, either by scientist or volunteers. There are works with more scientific character, like articles and books, and others specifically designed for volunteers and citizens, like citizen science programs [1– 19, 21 – 23, 25 – 29, 39].

In order to create a methodology for a plant phenology monitoring it is crucial to choose the basic specific scientific questions, sampling design and parameters to collect data that sustain the monitoring procedures [9 - 15].

In this chapter we focused our research on a methodological meta-analysis of the existing citizen science monitoring programs that could be found worldwide on fauna and flora phenology monitoring.

1.2. Meta-analysis definition

1.2.1. Research of methodological steps

Analysing the methodological steps of the existing initiatives [9 - 14] raised several questions concerning the monitoring design chosen by different programs. Since they are important key points to reflect before creating a new citizen science monitoring program, we proposed a meta-analysis of 9 methodological phenology monitoring steps (Table 2).

Table 2- Key point questions for the meta-analysis study

1	Observation method	Which is the best method to be used by volunteers?
		Should the use of digital camera be mandatory?
2	Monitoring scale selection	How many monitoring scales exist and which one is most used by volunteers?
3	Phenophase selection	Which phenophases are more suited for volunteers’ observation?
4	Names of the Phenophases	Which names should be used to help volunteers to identify the selected phenophases?
5	Species selection	How to select plant species for the monitoring study?

6	Monitoring sheets	What should the sheets contain to be easily understood and help the registration made by volunteers?
7	Observation Frequency	How many times should a volunteer observe the studied species?
8	Website	How to create a website on phenological monitoring that can help and guide the volunteers?
9	Data	How to store data on the website?
		How to help volunteers to collect data with quality?
		How to control the quality of the collected data?
		How to treat and publish data?
		When is the time to start using the collected data to analyse phenological trends?

1.2.2. First contacts with Phenological Monitoring Programs

In the beginning of the work, an email contact was made with PEP725 (Pan European Phenology Project) and Nature’s Notebook because of their extensive work and detailed experience on the subject, location and years of data collection, and their coordinators were very helpful and offered their assistance from the first moment.

Project Budburst was also selected because it is a program specialized in plant phenology, so their support would be important. Nature’s Calendar was also consulted because it is a program located in Europe (UK) and some of the plant species monitored are the same that we planned to monitor.

The available information collected during our bibliographic and web research on the worldwide existing phenological monitoring programs [1 - 3, 7 – 10, 13 - 15, 19, 22, 25, 26, 29] allowed the gathering of some answers to the questions above mentioned, but not all.

1.2.3. Questionnaire and Survey

To extend the information on the programs’ methodological options, a survey with a questionnaire, presented on Appendix III, was created and sent to a selection of programs identified after the research namely:

- Project Budburst;
- Nature’s Calendar;
- Nature’s Notebook;
- PEP725.

The questions placed on the survey were elaborated in a way to obtain simple, but justified answers that could explain their methodological choices.

The survey sent to the phenological monitoring programs coordinators mentioned before contained ten questions distributed in five categories related to the methodological steps. It is presented below.

Questions:
Observation Method:
1. Should the use of a digital camera be mandatory?
_____
(Why?_____)

Species Selection:
2. When you choose a plant species to monitor, what criteria do you use?
- Morphological features (Y / N)
- Conservation status (Y / N)
- Frequency representation of the plant on the study area (Y / N)
- Other:_____

(Why?_____)

Number of individuals to monitor for each species:
3. What’s the ideal number to use: _____
(Why?_____)
4. Have you established different numbers of individuals depending on the species to monitor? (Y / N)
Which?:_____
(Why?_____)
5. What’s the minimum number of individuals that each volunteer should register of each species:_____
(Why?_____)

Observation Frequency:
6. How many times in a year should a volunteer go to the study area to monitor a species?
_____
(Why?_____)

Data:
- **Quality Control**

7. How is the control of the volunteers’ data?
_____
(Why?_____)
8. Are training sessions essential? If so, how many should be done in a year?
_____
(Why?_____)

- **Process and Publication**

9. When calculating the mean of registers for each species, do we use all results, even if the monitored number for species by each volunteer is different, or not?
_____
(Why?_____)
10. When to start treating data on the phenological tendencies? (ex: 2 years or more?)
_____
(Why?_____)

Following, the answers received from the surveys were compared with our own methodological options and others found on bibliographic references [1 - 3, 7, 8, 15, 19, 22, 26, 25, 29], so that a comparison between the options of citizen science programs and scientific articles could be possible. With this comparison we expected to obtain important information and create a balanced methodology between citizen science objectives but also science-based options for our future monitoring project.

2. Methodological Design of “Serralves em Flora”

2.1. Background

To create a method for a citizen science phenological monitoring project for Serralves that could be replicated by volunteers but that is also scientifically well-based, required some attention and study. It was necessary to think about data complexity, data quality and interest of the data to be scientifically sustained and profited, among other things [8 - 14, 25 – 28]. So, designing the method for citizen science monitoring had to contemplate both volunteers’ characteristics and scientific demands. To work, it must comprehensively incorporate the needs of both sides.

2.2. Chronological steps for the Serralves Park project creation

1) Program research and contact – to obtain information about the existing phenological programs through search of their websites, works and email exchange. After this research was made, we aimed to establish partnerships between Serralves Park and the programs found;

2) Methodological steps – we adapted the 9 methodological steps that are required for the creation of a phenological monitoring project, as presented on Table 3.

Table 3 - Case study methodological steps adaptation

1	Observation method	Select a simple observation method for visitors to apply.
2	Monitoring Scale Selection	Selection of Serralves Park area as the study scale.
3	Phenophase selection	Selection of phenophases based on the meta-analysis of the options used by other programs.
4	Names of the Phenophases	Convert scientific phenophase names to user friendly designations.
5	Species selection	Create a set of selection criteria to apply to Serralves plant species.
6	Monitoring sheets	Develop monitoring sheets simple to use and follow by the volunteers. Test the monitoring sheets with the public.
7	Observation Frequency	Determine how volunteers are allowed to observe when they come to visit the park.
8	Website	Create a web platform with the species information and training and monitoring sheets, using the existing fauna platform as a model.
9	Data	Collection and Documentation – register the dates when a phenophase is occurring during observation. Deposit the collected data on the database of the project.
		Quality control – create several tools to control the quality of the

		data that is gathered by the volunteers.
		Process and Publication – treat the final data with the statistical analysis methods found during research and present the results in graphics and tables.

3) Test phases – we performed some tests to test the created monitoring sheets on different stages of development and with different public, to help correct the underlying errors. Two different test phases took place: (1) **test phase 1:** made by the “Serralves em Flora” project’s team to test the monitoring sheets presentation and registration method; (2) **test phase 2:** conducted on the 24th and 25th of April of 2015 during “Serralves BioBlitz”, a public event that Serralves Park developed for flora and fauna inventory. Public adhesion and the phenophase definitions were tested, as well as the design of the monitoring sheets.

Pilot selection of species to test was made using the following criteria:

- Type of monitoring sheet – we developed a total of 5 types of monitoring sheets depending on the number of phases to observe and how many times a year this phases occurred (Type 1 – 4 phases to observe; Type 2 – 3 phases to observe; Type 3 – 2 phases to observe; Type 4 – 1 phase to observe; Type 5 – the phases repeat several times along the year);
- Flowering season – the time of the year that the species starts and ends the flowering phase;
- Fruit ripening – the time of the year that the fruits of the species are ripe;
- Location in the park – the place where each species is located on the Serralves Park;
- Presence in the identification key guide – another activity of “Serralves BioBlitz” program was connected to the identification of the flora of the park using with an identification key guide. Therefore, the connection between this identification activity and “Serralves em Flora” monitoring project, allowed a shared pool of species in both activities.

For this purpose, a table was created, in Portuguese, with these criteria and the 22 selected species (Appendix X).

4) Analysis of the results obtained – we analysed the results from the field surveys, the statistically treated data and the results from the test phases. These results can help to correct the errors that the volunteers make during

observation and, over some time, the changes of the plant phenology of the park.

5) Adjustments and restatements – after all the tests and analyses of the project, we adjusted all the work sessions that presented problems and corrected the materials that led to incorrect data on the observations.

III. Results

1. Results of the meta-analysis of the existing programs

The results presented were obtained through the surveys made, through bibliography and from the questionnaire sent to programs coordinators. Since only one of the selected programs (USA-NPN: Nature’s notebook) responded extensively to the survey, the other answers were obtained using 9 collected articles [1 - 3, 15, 19, 22, 25, 26, 29] (the ones related to a more scientific phenological monitoring programs) and 2 guide materials from programs [7, 8].

1.1. Observation methods

The results of the question asked on the survey about the mandatory use of the digital camera on the observations presented on Figure 2 [1 - 3, 7, 8, 14, 15, 19, 22, 25, 26, 29].

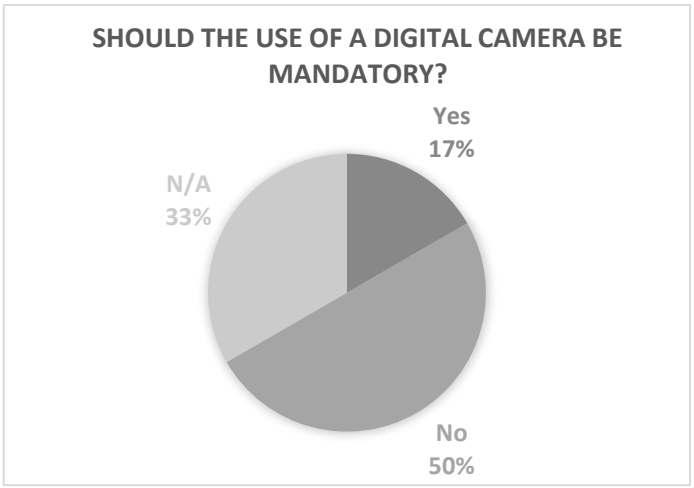

Figure 2 - Survey answers for the first question. (N/A – not available information)

The majority of the answers were negative, while only a small percentage (17%) defend the mandatory use of the digital camera on field observations. A considerable percentage of answers are blank, since the respective works did not mention this method option.

1.2. Monitoring Scale Selection

The programs and articles analysed used certain types of study areas, depending on the type of works. As for the articles, some of them used specific gardens created

for phenological studies [1, 2], while other selected city gardens that possessed specific species that they were observing [3, 19, 29].

The programs, guides and an article analysed [7 - 15] showed a different study area selection. The study area can go from house gardens, city gardens, botanical gardens, nature reserves and even the wild habitats.

The volunteer is the one that selects the study area, using the distance between their base (workplace or house) to the study place. A study place within 1.5 - 2km radius of distance should be ideal, but longer distances can still be accepted although a distance limit should exist, or the volunteer would have difficulties to frequently visit the area (possible limit can be 5km) [7]. For this free choice of study areas there is only a condition that programs expect the volunteers to follow, which is the GPS coordinates of the selected place so that they can register the place on their database so that they know where the collected data is from [2, 7 - 15].

1.3. Phenophase selection

The programs, guides and articles analysed [2, 3, 7 – 10, 12 - 14, 30] showed that all phenophases follow the BBCH (“Biologische Bundesanstalt, Bundessortenamt und Chemische Industrie”) list. The BBCH list contains a list of the different phases of the life cycle that can be observed in several plants species, mostly species used in agriculture, and is used worldwide to identify the phenological development stages of a plant [30]. The most selected phases consist in the beginning or ending, or both, life cycles events (leaves, flowers and fruits) [3, 7 – 10, 12 – 14], while other may also consider the use of phases that occur in the middle of them (an example is the full flowering phase) [2, 3, 7, 8, 14].

1.4. Names of the Phenophases

From the analyses made on the research material [2, 7 – 10, 12 – 14] it was visible the name adaptation of the selected phenophases from the BBCH list. The definition of the phase was also altered to give volunteers a better explanation of it.

Four types of adaptations to the phenophases names were found. The first one only changed the name and definition, where the new name was similar to the BBCH one, but was easier to understand [10, 12, 13]. The second type also changed the name and definition: the name of the phase was more generalist, and was associated

with the “start” and “end” words to describe the beginning and ending [8, 9, 14]. The third type changed the name and definitions, but presented them in form of questions [14]. The last type changed the name and definition, but also created acronyms related to the type of phases of the life cycle (acronyms for leaf, flower and fruit phases) [2].

1.5. Species selection

The programs and works used in the survey were asked which criteria was used when selecting a plant species to monitor. Figure 3 presents the answers [1 - 3, 7, 8, 14, 15, 19, 22, 25, 26, 29].

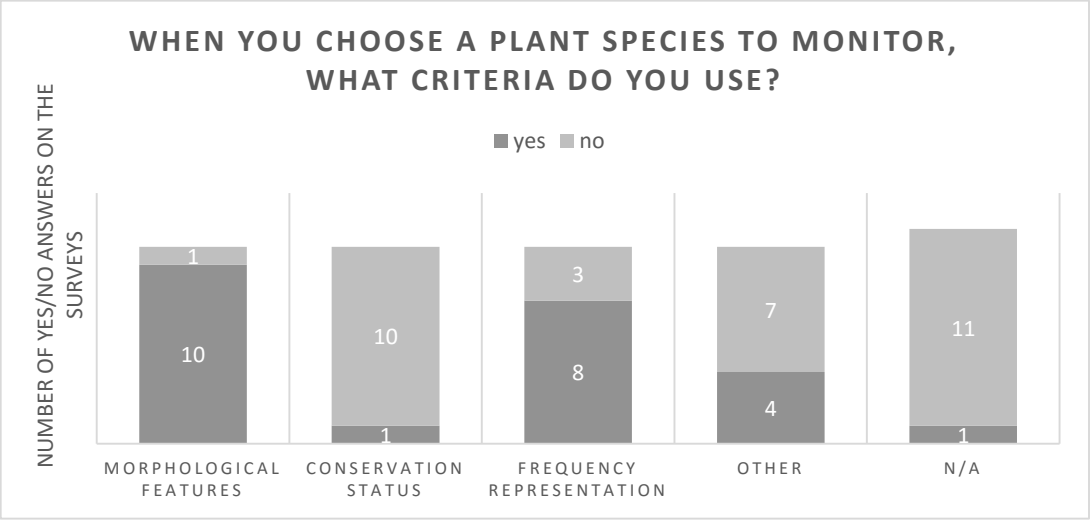

Figure 3 - Survey answers for the second question (N/A – not available information).

The three defined criteria presented (**morphological features, conservation status** and **frequency representation**) were chosen as general categories for the fact that they were mentioned, directly or indirectly, in several works. The answers from the program, articles and guides show that the major criterion for species selection is the morphological features, followed by the frequency representation. Conversely the conservation status is not much used as a species selection criteria on these works. Few works consider the use of other types of criteria with the general categories presented here or even other categories. From the 12 selected works only one did not contain any information about this theme.

The next three questions presented on the survey are connected to the **frequency of representation** of the species. Regarding the ideal number of individuals to monitor

each species, answers are presented on Figure 4 [1 - 3, 7, 8, 14, 15, 19, 22, 25, 26, 29].

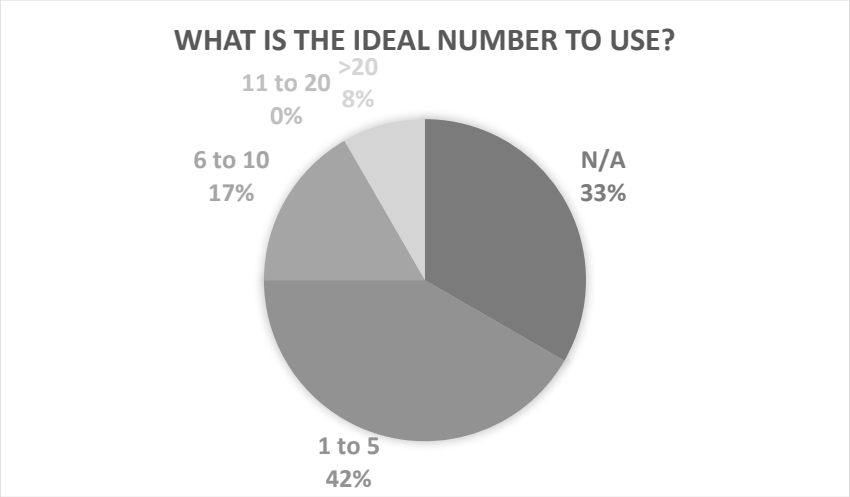

Figure 4 - Survey answers for the third question. (N/A – not available information)

A large amount of answers were missing, since several works did not contain information on this topic. From the remaining answers, the most selected, with 42%, was the 1 to 5 interval, followed by the 6 to 10 interval. For the remaining two, the 11 to 20 interval is rarely chosen, while the option of more than 20 individuals is not even used.

Regarding the question on the difference on the number of individual to monitor established depending of each species, Figure 5 shows the answers [1 - 3, 7, 8, 14, 15, 19, 22, 25, 26, 29].

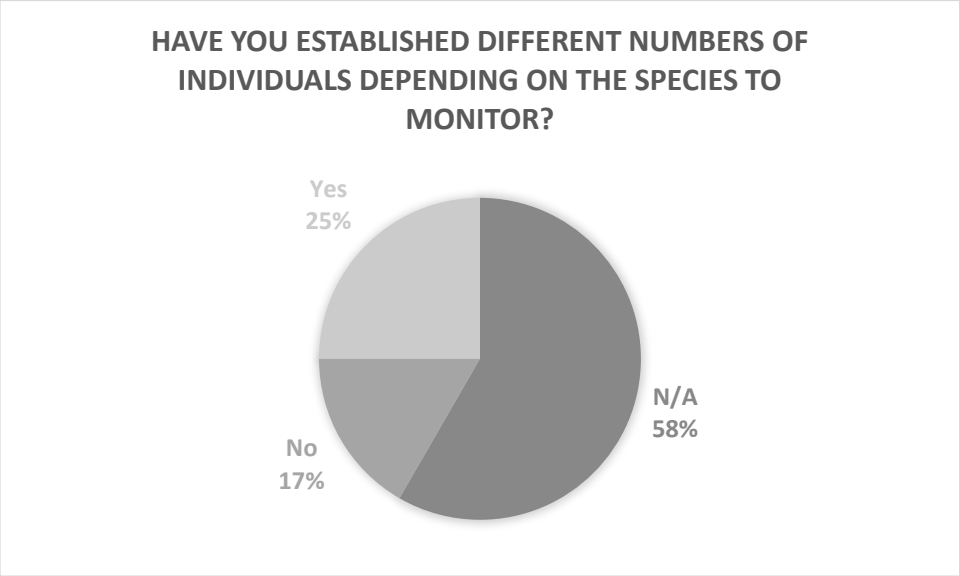

Figure 5 - Survey answers for the fourth question. (N/A – not available information)

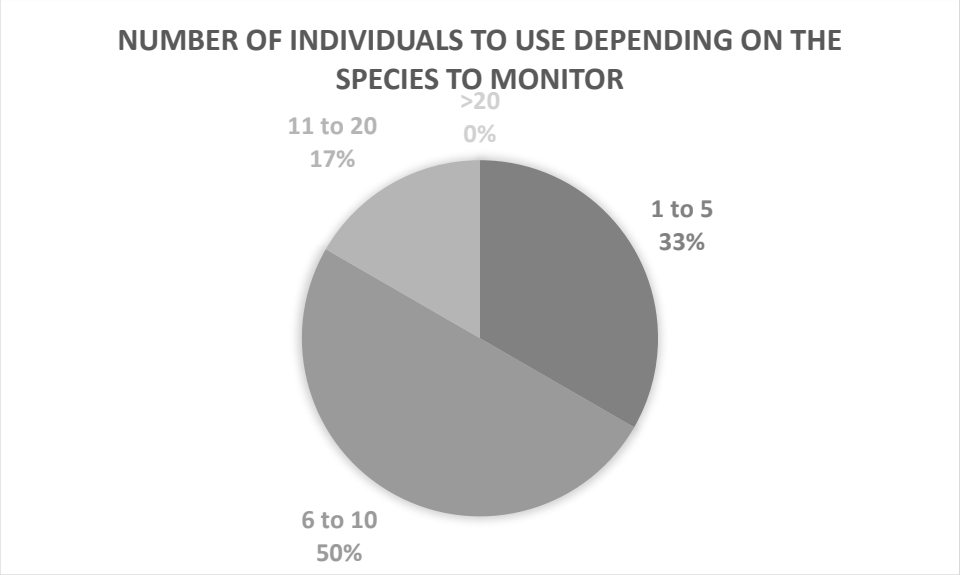

Figure 6 - Survey answers for the question about the number of individuals to use depending on the species

Figure 5 shows that more than half of the answers are blank because these works did not contain information about this topic. A quarter of the answers show that, depending on the species, different numbers of individuals can be used, while the remaining answers use the same number of individuals for all species.

The projects that answered positively, were asked about the number of individuals used for different species. The answers, presented in Figure 6, show that the most common number of individuals to use per species goes from 6 to 10.

In the last of these 3 questions it is asked the minimum number of individuals that a volunteer should register for each species. The answers are in Figure 7 [1 - 3, 7, 8, 14, 15, 19, 22, 25, 26, 29].

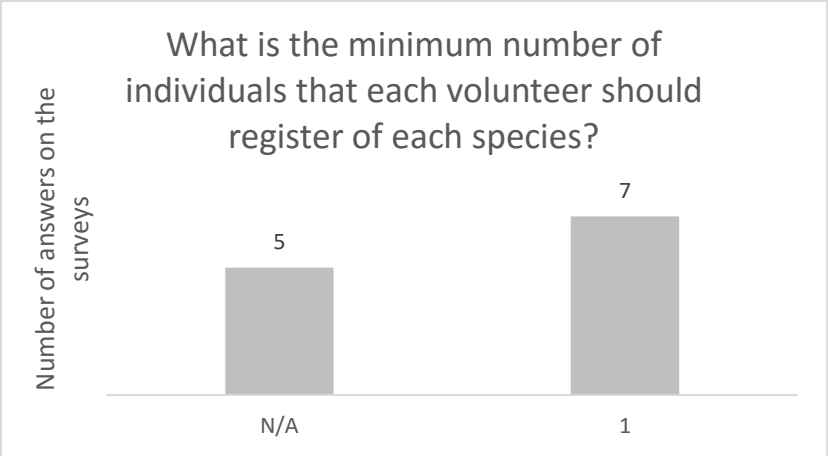

Figure 7 - Survey answers for the fifth question. (N/A – not available information)

On the works that refer to the minimum of individuals to record for each species all of the answers were are the same: 1 individual. The remaining answers are blank because the respective works did not contain information about this topic.

1.6. Monitoring sheets

Different types of monitoring sheets were found, depending on the program, which means that there are different options to register the data of the observations [9, 10, 12 - 14]. From the programs analysed [9, 10, 12 - 14] there were 2 types of monitoring sheets. The first one is an observation sheet where the volunteers only register the dates of occurring phenophases [9, 10, 12]. The other type consists in observation sheets where the volunteers register the dates of the observations and, for each date, register the presence/absence of the listed phenophases [9, 14].

The Budburst program [9] is the only phenological program that possessed these 2 types of monitoring sheets, depending on the type of observation that the volunteers wants to make. If it is a less frequent observation, called single report, the type of monitoring sheet is the one were presence/absence is used. For a more frequent observation, called regular reports, the other type of monitoring sheet is used.

1.7. Observation Frequency

The frequency that a volunteer should go to the study area and observe the selected species is an important matter to take into account, yet it is not always mentioned in articles or programs. Figure 8 conveys the collected answers regarding the how many times in a year should a volunteer go to the study area and collect data.

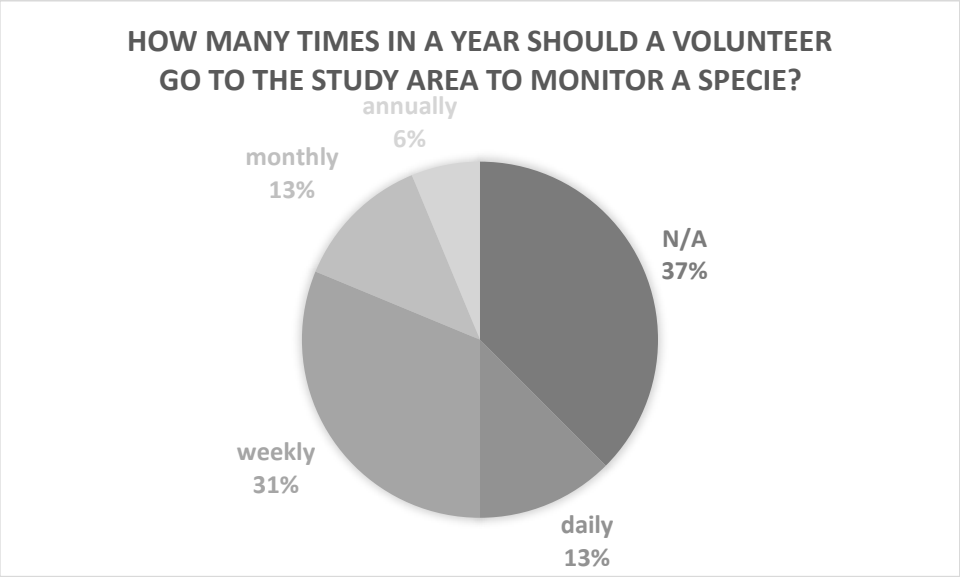

Figure 8 - Survey answer for the sixth question. (N/A – not available information)

The majority of the answers are blank because this topic was not present. The most selected answer is the weekly visit to the study area, followed, in the same proportion, by the monthly and daily visit. The annual visit is less preferred. Each work selected more than one answer, since the choice depends on which season of the year the visit is made.

1.8. Website

The websites of different programs studied looked different because of the aesthetics, but in terms of information available they were quite similar. The majority of the phenological monitoring programs uses the website as a tool to give information and knowledge to volunteers about phenology, monitoring and even species information sheets and monitoring sheets that can be used for data registration. It may also contain observation guides for volunteers to use on the field [9, 10, 12, 14]. The websites are also the place where the database for the data input and output is placed, allowing visitors of the website who created an account there to download the treated data of several observations for each observed species [9, 10, 12 - 14].

1.9. Data

a) Documentation

Data collected by the volunteers to be used in studies needs to be placed on the database of the website. The data registration is quite similar among the different programs. In all of them the volunteer is required to create an account, so that his/her name can be linked to all his/her observations. After that, the volunteer must fill the fields presented on the site, the species observed, the dates of observation and the phenophases observed. [9, 10, 12 - 14]. There can be some cases [13] in which the phenophase and the plant code can be asked as an additional field - it all depends on the data storage system present on each program.

b) Quality Control

There are several ways to control the quality of the data collected by volunteers, since each program created their own methods. There are, however, some simple methods that are used by the majority of the programs. In the survey there are 2 questions about this topic. The first one asked how the control of volunteers’ data is made. Some selected methods, the ones most used among the research made [9, 10, 12, 14, 15, 26 – 28] were provided as possible answers. Figure 9 presents the answers [1 - 3, 7, 8, 14, 15, 19, 22, 25, 26, 29].

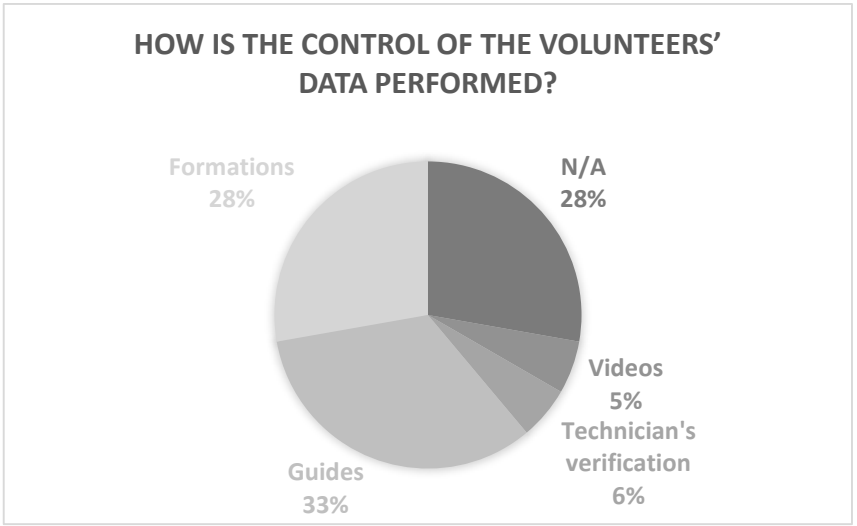

Figure 9 - Survey answers for the seventh question. (N/A – not available information)

The most selected methods are the guides that each program and project creates. Formations (trainings) are next, followed by the technicians’ verification and the videos, respectively. The remaining 28% belong to the works that did not possess information about this topic.

The second question refers to the practical aspects of the training sessions. It was asked if training sessions are essential and, if so, how many should be done in a year. Figure 10 shows the answers of the works that use formations as a method to control data quality.

Figure 10 - Survey answers for the eighth question. (N/A – not available information)

The majority of the works answered positively, although none of them could indicate a number of training sessions per year. As for the remaining answers, half of them did not think that training sessions are essential and the other half did not possess any information about this topic.

c) Process and Publication

After the quality control, the collected data is ready to be used in studies of climate change, which means that it is organized and processed so that trends and changes of the phenophases dates can be presented in tables and graphics for publication. Two questions emerged when going through the bibliography on this topic, which were placed on the survey. The first one is focused on the method for calculating the mean of records for each species, that is especially important when the monitored number for each species by each volunteer is different. The answers are presented on Figure 11.

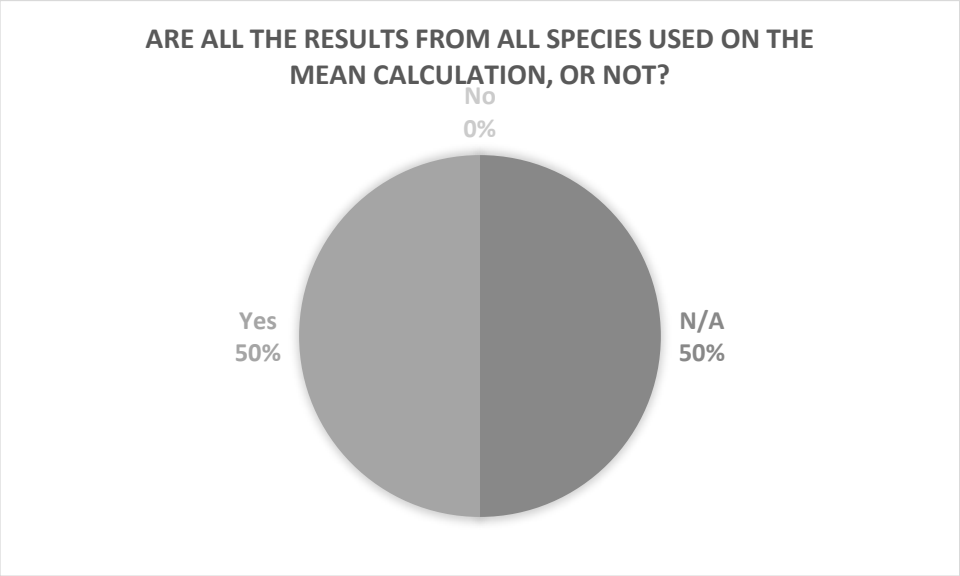

Figure 11 - Survey answers for the ninth question. (N/A – not available information)

There are only yes and blank answers, the same number of answers for each. All works were used to answer this question, even the ones presented in Figure 4 that did not possess information about the number of individuals established in the work.

The second question refers to the ideal time to start treating the data for the phenological tendencies. Figure 12 shows the answers.

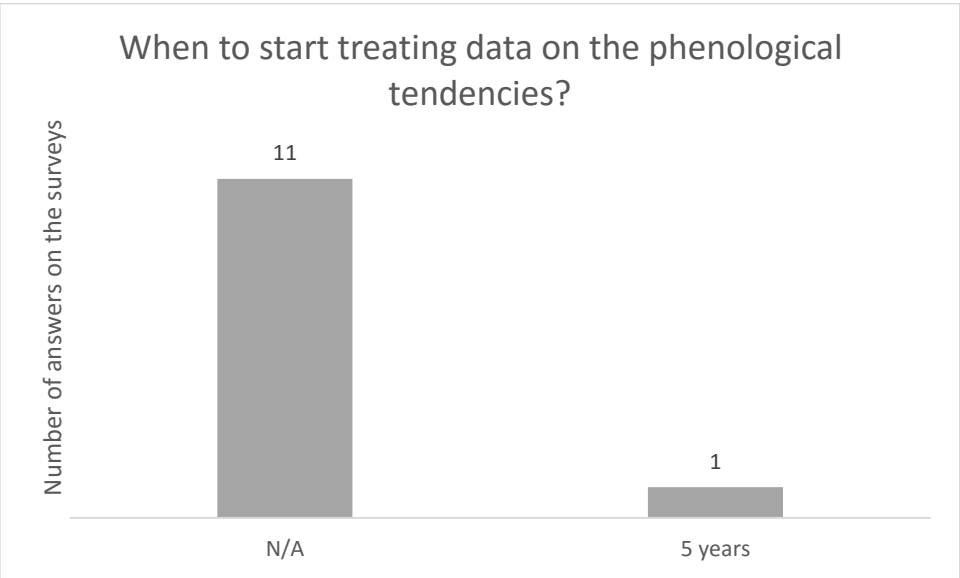

Figure 12 - Survey answers for the tenth question. (N/A – not available information).

As shown in the graphic, this topic is not usually mentioned in phenological monitoring works, so most of the answers are blank. Only one work mentioned this

topic, answering a period of 5 years, as the ideal time frame to wait before starting to treat data as a dataset that reveals sustained trends on phenological changes.

2. Partnerships established with phenological monitoring programs

As mentioned before, partnerships between phenological monitoring programs and networks involving citizen science are vital to establish contacts and learn from others’ experience. In this way, in the beginning of this work, we suggested that Serralves Park contacted the different programs found during research [9, 10, 12 - 14] for a possible partnership (the email exchange for each program can be seen on Appendices IV and V). As a result, two programs’ contacts responded to the request: Nature’s Notebook and PEP725.

The Nature’s Notebook program (associated with the USA-NPN network) [14] was the first program to accept the request, allowing the data flow between both programs and giving help with any question that may occur during the project development.

The PEP725 program [13] also accepted the request, also allowing the data flow between both programs, and the opportunity for Portugal to possess a registered phenological station in Serralves Park linked to the European phenological monitoring database used for climate change studies.

In the future, Serralves Park will share their data with both programs and it will become an official Portuguese phenological station in the European phenological database.

3. Results of the design of “Serralves em Flora”

3.1. Naming “Serralves em Flora”

“Serralves em Flora” is a citizen science phenological monitoring project that has been created for Serralves Park. This project’s objectives consist in monitoring certain plant species that are present in the park and assessing how the climate change could eventually affect their phenophases.

The name given to this project (“Serralves em Flora”) was carefully thought. The project name needed to efficiently pass along to the public the idea that Serralves Park would have a new activity connected to the park’s flora study but also in line with the existing well-known annual festival of art, named “Serralves em Festa” which brings to the Park thousands of people. With the selected name we hope to raise curiosity and achieve the promotion purposes of the phenological monitoring program.

3.2. Observation Methods

To begin a project of this sort, it is important to think about what kind of observation methods will be used for the monitoring process. It must be something that can be replicated by everyone, in any place and scale and with easy access, but at the same time it must be precise enough to give accurate and reliable data [6 – 10, 12 – 14]. From the three methods found (digital repeat photography, satellites capture and direct observation and registration) [9, 10, 12 – 15, 21, 22] the one used by phenological programs and that fulfils the criteria mentioned above is the direct observation and registration.

For “Serralves em Flora” study, after careful and reasonable resource analysis, we decided to use the direct observation and registration method with photography support. The reason consists on the fact that sophisticated monitoring materials tend to be difficult to get and, in the case of people with no training nor formation in the area, difficult to use [9, 10, 12 – 14, 21, 22, 26, 27].

To minimize the possible registration of incorrect data by volunteers, the use of digital camera would be a requirement in “Serralves em Flora” project. Volunteers should take photos of the observed phenophases, submit the photos to the database along with the observed data and an expert should compare the data with the photograph to see if they match and this way validate the observations [1, 15]. The selected method is the most simple and accessible for everyone to collect data and,

with the photography component (digital camera or cell phone camera) control the quality of the collected data [1, 9, 10, 12 - 15].

3.3. Monitoring Scale Selection

Since the data collected would be used for scientific studies, having different study areas through the globe would allow to obtain data in a global scale [2, 25 – 28]. When choosing an area there are 3 factors to have in mind: the access and convenience of the site, the stability of the habitat, and the influence of human activity [1, 7, 13]. In the research made [2 – 4, 6 – 10, 12 – 15, 29] and regarding the method selected, monitoring places were usually parks and city gardens, which are good places, with a lot of visitors, who can became volunteers, and with a lot of species to study, native or exotic. But in other cases, volunteers cannot access the selected study area. In that cases, the study area should be brought to them, which means, the monitoring program should cover other location types that can benefit the volunteers (as house gardens or city gardens close to their residence), allowing a larger scale study area [8 – 10, 12 – 14, 17, 23, 29]. Serralves Park is a private historic garden for public use located in the Oporto city, which is easily accessed by all visitors willing to participate in the monitoring program, so the scale of this monitoring project is a local one.

3.4. Phenophase Selection

The **phenophase selection** takes into account particularly the cycle of plants during the year in Serralves Park. In Spring, most plants start to bloom and in Autumn the leaves start to fall. These are the sorts of events that are interesting to register, since the changes are quite visible. So, the most important phenophases should focus on the leaves, the flowers and the fruits since they represent the most visible changes on the plant [2, 3, 5 – 10, 12 – 14, 16, 29, 30].

Based on the research made [2 – 8, 15, 16, 29, 30], the selected phenophases and corresponding definitions for “Serralves em Flora” project were:

- First leaf unfolding – when the first leaves of the tree/shrub are fully opened.
- Leaf unfolding – when about half of the tree/shrub leaves are fully opened;
- First flowers open – when the first flowers of the tree/shrub are fully bloomed.

- Full flowering – when about half, or more, of the tree/shrub contains fully bloomed flowers. Some of the petals from the first bloomed flowers may already started to fall off;
- Flowering finishing - when most of the tree/shrub flower petals have fallen or got dry;
- End of flowering –when the first fruit sets became visible;
- Beginning of ripening – when the first fruits start to change its original colour to his mature colour;
- First ripe fruits – when the first fruits with the colour and the appearance of a mature fruit appear;
- Fully ripe fruits – when more than half of the fruits of the tree/shrub are fully mature. They start to fall naturally;
- Leaves beginning to discolour – when some of the leaves start to lose their original colour;
- Autumnal colouring of leaves - when half, or more, of the leaves of the tree/shrub lose their original colour, including the ones that have already fallen;
- Autumnal leaf fall – when half of the leaves of the tree/shrub have fallen;
- End of autumnal leaf fall – when almost all the leaves (95%) of the tree/shrub have fallen.

Overall, these phenophases will be displayed for all the species selected for the Serralves case study. But since the species list contains different kinds of species, like deciduous and evergreen trees and shrubs, different adaptations will be made to the phenophases, so that there is a specific monitoring sheet, showing only the available phenophases selected and specifically adapted for each plant species. For the coniferous species, there will be slightly different phenophases selected based on the research [9, 14, 15]. These phenophases are:

- First seed cones – when the first female cones are visible on the tree;
- First ripe seed cones – when the first female cones become covered by a red and fleshy aril (pseudo-fruit);
- Full ripe seed cones – when more than half of the tree is covered with mature arils. Beginning of the natural fall of the seeds and the arils.

After the partnership established between Serralves Park and PEP725, the names and codes from the phenophases were based on the phenophase list from PEP725, together with the BBCH list [13, 30]. Nevertheless, the phenophase definition for each

particular species was a specific adaptation from the definitions encountered on the several monitoring programs and the BBCH list [9, 10, 12 - 14, 30]. This adaptation was created to simplify the original complex, and not always specific, phenophase definition, allowing a better understanding for the volunteers participating in “Serralves em Flora”.

3.5. Names of the Phenophases

The **denomination of the phenophases** was a very important concern in the design of “Serralves em Flora”, since working with people initially disconnected with this area requires a communication method understandable for both parts (citizens and scientists). The new names should be simpler and easy to communicate by the trainer and understand by the volunteer. However the denominations must be accurate and correspond to the phenophase name and definition on the BBCH list [9, 10, 12 - 14, 28, 30].

Therefore, after establishing the phenophases to monitor in “Serralves em Flora” it became necessary to use more explicit names and codes and then create a table to convert the BBCH codes to “Serralves em Flora” ones. These changes, presented on Table 4, are in agreement with the BBCH names and codes and as in the monitoring sheets (Portuguese language).

Table 4 – Correspondence of the former phenophases codes and names to the new ones. (BBCH code – worldwide code number for the phenological development stages of plants)

BBCH Code	Scientific name	New code	“Serralves em Flora” name
11	First leaf unfolding	FO - 1	“Desenrolar das 1as folhas”
13	Leaf unfolding	FO - 2	“Desenrolar das folhas”
60	First flowers open	FL - 1	“Início da floração”
65	Full flowering	FL - 2	“Floração intermedia”
67	Flowering finishing	FL - 3	“Floração final”
69	End of flowering	FR - 1	“Início da frutificação”
81	Beginning of ripening	FR - 2	“Início de maturação dos frutos”
86	First ripe fruits	FR - 3	“Maturação dos 1os frutos”
89	Fully ripe fruits	FR - 4	“Maturação completa dos frutos”
92	Leaves beginning to discolour	SE - 1	“Início da coloração de Outono”
94	Autumnal colouring of leaves	SE - 2	“Coloração de Outono”
95	Autumnal leaf fall	SE - 3	“Queda outonal”
97	End of autumnal leaf fall	SE - 4	“Fim da queda outonal”
N/A	First seed cones	CO - 1	“Aparecimento dos 1os cones femininos não maduros”
N/A	First ripe seed cones	CO - 2	“Maturação dos 1os cones femininos”
N/A	Full ripe seed cones	CO - 3	“Maturação completa dos cones femininos”

The new codes created contain key letters that represent the different parts and events of the plant: FO – folhas (leaves); FL – flores (flowers); FR – frutos (fruits); SE – senescência (senescence); CO - cones. The numbers that follow these key letters represent the number of the phenophase to which the event belongs. This new code structure will simplify the process of the data registration on the database, since the registration codes for the phenophases are the same as the ones on the monitoring sheets. No BBCH code was found for the seed cones phases so, for these 3 phases, the BBCH code space is in blank (N/A) and the data registration of these 3 phases will only use the new code.

Using the same type of presentation used by the USA-NPN program [14], each phenophase name and definition is presented in the form of a question in the registration table, in order to facilitate understanding by the public

3.6. Species Selection

The next step was **species selection**. Usually, there are mandatory characteristics in the selected plants, either morphological features or the high frequency of the species on the study area. Criteria found on the research made [1, 2, 7 - 10, 12 - 14] to select the plant species include the following:

- The phenophases of the plant should be easily recognised and observed;
- The phenophases of the plant should be sensitive to air temperature;
- The plants should have some importance at economic level;
- The plants should be distributed on a large geographic scale;
- The plants should propagate easily;
- The plants should have flowering stages to be more attractive to the study;
- The plants should be familiar to the volunteer that wants to study her, so that they can recognise her more quickly;
- The existence of a large number of individuals of the same species within the study area that present the same age and similar characteristics and conditions of growth.

Regarding the last topic, the **number of individuals to monitor for each species**, the most common option is to create an interval with a minimum number and a maximum number that must be registered. The minimum is usually “1”, since one of the

objectives of the program is to be used even in house gardens, where it is very likely the existence of only one exemplar for each species. The maximum number is usually “5”, being the most cited ideal interval “between 3 and 5”. It is likely that most gardens/parks contain at least 3 to 5 individuals with similar characteristics for each species. With that number, it is possible to perform a study with scientific significance [6 – 8, 14].

To select the species for “Serralves em Flora”, a species table was created, based on the criteria found on the research made [2, 7 – 10, 12 - 15]. It was also established an additional criterion to adapt the selection to the case study – this criterion was that the monitored plant should be a woody plant (a shrub or tree). Although the other programs and articles [4, 6 – 10, 12 – 17] included herbaceous plants on their studies, we decided not to use the herbaceous life form because of the gardening management that Serralves Park goes through permanently and that would influence the study.

The selection table (Appendix VI) contains a column with a list of all the species that exist in Serralves Park and some of the criteria used to select the species. In total, there were 8 criteria, 5 of them crucial for the selection:

- Life Form – the classification of a species as a tree, shrub or herbaceous plant. This was the **first crucial criterion** for our monitoring study. For us it was important to study individuals during several years, which is not possible for herbaceous life forms;
- Biogeographic Distribution – the classification of a species as native climate is Temperate, Mediterranean, Continental or Sub -Tropical;
- Origin – the classification of a species as native from Portugal or exotic. This was the **second crucial criterion**, since it allowed a better global comparison of species with different geographic origins;
- Invasive Nature – the classification of a species as an invasive species or not;
- Present structures and visibility – the presentation of a species’ structures (leafs, flowers and fruits) and if these structures are visible, or not. This was the **third crucial criterion** because if these phenophases cannot be easily seen by the public, then these would be missed and the monitoring would be incomplete. It was also considered the size that the individuals usually reach - for the volunteer to observe phenophases of the bottom and the top, of plants that are too tall, becomes almost impossible, so the species has to be excluded from the selected pool;

- Number of individuals – the number of similar individuals available in Serralves Park for each species**. This fourth crucial criterion** determined if a species could or could not be monitored. Since the ideal number established for “Serralves em Flora” ranges from 3 to 5, species with less than three exemplars in the Park were excluded from the project. This criterion was applied on the park, while observing the plant species of the list;
- Conservation Status – if the species as any conservation concern or not;
- Individual’s proximity and access – the individuals of the same species located in the same area of the park, which can be easily accessed by visitors. This **last crucial criterion** determined from all existing individuals of each species present in the park, which ones should be selected for the study. This criterion was applied on the park, while observing the plant species of the list.

In “Serralves em Flora” there were 4 species that, despite not fulfilling the criteria mentioned above, were also added to the selected list. These species were *Buxus sempervirens* (boxwood), *Laurus nobilis* (laurel), *Quercus robur* (English oak) and *Taxus baccata* (yew) and they were selected since they are common species or seen as emblematic species in the country.

- *Buxus sempervirens* was chosen because it is a plant species that possesses a slow growing rate, and it is relatively rare to be seen in its wild state in Portugal [42]. During the Tertiary, the glaciers covered great part of Europe, leading some species to extinction, and others to adapt to the changes that the glaciers created. *Buxus sempervirens* is one example of this situation, and still exists on the present days, showing to the world a little bit of the history of adaptation and evolution. This species was also chosen because of its curious uses. Its wood, thanks to its physical properties, was used to create musical instruments a long time ago, like the flute and the bagpipe [40, 41];
- *Laurus nobilis* is an abundant plant species in Portugal and in Serralves Park. It is very much used in the Portuguese gastronomy, and its leaves also contain medical properties. In ancient times the leaves where used in ancient Rome to create symbolic crowns, the famous laurel crown. Its unique fragrance and the ability to repel insects for the other near plants where enough reasons to promote its abundant plantation along the Mediterranean basin [40, 41];
- *Quercus robur* is one of the most abundant in Serralves Park and is a symbol for Portugal, since it is one of the most abundant species in the north of Portugal. This species represents strength and resistance. Its lumber was and is still used for the construction of furniture and casks for aging wine. [40 - 42];

- *Taxus baccata* is a species native to Portugal that its being disappearing over the time. The toxins in the entire tree, except the fruit, are a potential threat to humans and animals, so they have been removed from the wild. Although it is considered a danger, the lumber was used in the past to create bows and crossbows, and in the present days is used for the construction of furniture pieces. The taxol is used in studies of the fight against cancer, which can create a motive to stop this species’ removal from the wild [40 - 42].

From the original 201 species present in the park, 22 were selected for this project (Appendix VII).

3.7. Monitoring Sheets

The next step was the creation of the **monitoring sheets** that will be used for the phenological monitoring. Since there are species that have different phenophases or characteristics, it was crucial to adapt each sheet to each species so that the data collected would be accurate [6 – 10, 12 – 14, 39].

The monitoring sheets for “Serralves em Flora” were based on the existing sheets of other phenological programs [9, 10, 12 - 14], but were adapted for the species of Serralves Park. Afterwards, we performed some preliminary tests with the draft monitoring sheets, observation and registration tests, to check the suitability of the sheets (phase 1 of tests). The species used for the preliminary test were *Cydonia oblonga* (quince tree), *Prunus persica* (peach tree) and *Tibouchina urvilleana* (princess flower). During the visit to the park in April 2015, these 3 species were showing the occurrence of some phases, so it was decided to use them to test the monitoring sheets. This test allowed the detection of some problems that could lead to misinterpretation and confusion, resulting in errors on the phase registration. After this, several modifications were made on the monitoring sheet to solve the problems encountered. The final version of the monitoring sheet of “Serralves em Flora” presents the following information:

- Introduction – a small text that explains the purpose of this work to the volunteers, guidelines for proper monitoring practice, including instructions on how to register observations;
- Name of the species - both common and scientific name are required;
- Location where the data was collected – primarily, the monitoring sheets will be used in Serralves Park. Nevertheless, in case people wish to use them

outside the park (other public or private properties), the location should be designated in the monitoring sheet;

- Serial number of the species exemplars – the numbers that are given to each plant present in the park. These numbers are connected to the database and can be used to locate a plant on the Serralves’ flora platform;
- Species locations on a map of Serralves Park – a portion of the map of the park that shows the location of the species exemplars;
- Registration table – a table that contains the exemplars in each column and the phenophases to identify in each line. Each phenophase contains the corresponding colour, code and definition created. The table and the phenophase definition are written in the form of a question, captivating more the volunteers and lowering the difficulty of the phenophase identification. The volunteers should register the date of the observation, followed by the presence/absence of the phenophases presented on the table for each exemplar of each species. The presence/absence should be written with S (“sim”, meaning yes) or N (“não”, meaning no) respectively. The data registration table contains lines and columns where the several phenophases and blank spaces for data registration are present.

Moreover, for a new volunteer in the monitoring process, and even for those with practice, it is still required to include some guidelines to help them [25 - 28]:

- Image guideline – located after the record sheet, it contains photographs to help to recognize the phenophases pointed at the record table. The images are photos already taken to the same phenophases that the volunteer is monitoring, allowing him/her to know how they looks like;
- Phenophase description – the last part of the monitoring sheet, or together with the phenophase name in the registration table. It describes in a simple, but at the same time with scientific terms, each selected phenophase, so that the viewer gains some new knowledge about the work that he/she is doing and also for him/her to be able to recognise them in different plants that he/she may pass by.

It is important to mention that, since the study area is located in Portugal and the future volunteers are Portuguese, the monitoring sheets were written in Portuguese to be easier for them to understand all the information (Appendix VIII).

Although these monitoring sheets were fully adapted for Serralves Park, they can still be used to monitor other study areas that volunteers may select. The volunteer only needs to make minor adaptations on certain fields of the sheet:

- Location where the data were collected – the volunteer should write the type of study area (house garden, private garden…), the name of the new study area if there is one (some city gardens possess names) and the GPS coordinates, so that the location can be register in the database as a possible study area to be monitored;
- Serial number of the species exemplars – if the new study area has an identification system that marks the plant species that exist there, then the volunteer should register the identification number or mark that is associated with the species. If there is no identification mark, the volunteer needs to inform the precise location, with a photograph, of the species’ individuals that he/she is monitoring;
- Species locations on a map – the volunteer can use the study area map, if there is one, to inform the location of the species to observe and the number of individuals encountered. In the case of the lack of a study area map, the volunteer can use other utensils, as the satellite tool from Google [43], to create a map for the study area and to mark the species’ location. In both cases, the map should be sent to the database along with the phenophase photographs and registration.

3.8. Observation Frequency

To enable volunteers to learn how to detect when a phenophase is happening, it is advisable for them to **frequently observe** the plant that they are monitoring. Usually, training programs demand that observation occurs at least once a week [6 - 8]. Some guides [8] advices that in some seasons, like Spring and Autumn, it is better to carry out daily observations, since the changes can occur in a high speed with favoured climate conditions. In the seasons of slower changes, two to three days a week of observations should suffice. It is also important to pay attention to the time of the day when the data is recorded. It is better if the volunteer established a time of the day for collecting data that can be the same for every record [2, 7]. To select the time of the day it is important to account for the light, visibility and the time of some phenophases. The light and visibility influence the colour of the plant on the human eyes so, a time of the day when the Sun is already high and behind the observer is desirable, since it will

not interfere with the data collected. Now it is necessary to conciliate this with the time of some phenophases. For example, some plants only bloom in the late morning, so if the data monitoring would occur in the morning, it would be much likely to miss this phenophase. So, it is important to study the plant cycle before deciding which time of the day to use to perform the data collection [7].

Monitoring programs can advise about this matter, but, ultimately, it is the volunteer who makes the final decision, since he/she is limited by his/her own life schedules. Since Serralves is a private park, visiting it every day would be difficult for the volunteers, not to mention that they have a daily schedule to follow, which leaves them with little time to spare for a daily observation. So, the observation frequency should be once a week or less [6 - 8]. In the end, it is still dependent on the time that the volunteers have for the program.

To analyse the impact of climate change on plant’s phenology it is required a long term monitoring study, so it is expected that this project continues over the years, with the help of the volunteers, in order to detect eventual changes over wider time frames. Since this is a citizen science project, the visitors that go to the park could be the ones (if they agree to help) that will be the volunteers monitoring plant species phenophases, collecting the data and storing information on the website of the project. It is expected that with this contribution, they can gain new knowledge about how climate change could influence the world’s flora.

3.9. Website

Serralves Foundation already created a citizen science platform (“Biodiversidade e Ambiente”) for fauna, so it was necessary to create a new module for the flora monitoring and also to embrace the “Serralves em Flora” project in the web platform. The structure of the “Serralves em Flora” new module would be similar to the existing programs, containing a simple introduction to several concepts (phenology, citizen science, monitoring…), a list of the species, with the corresponding information (descriptions, phases, event dates…), photos and monitoring sheets of the species and a map of Serralves park with the location of every individual of every species existing in the park. This map will allow the visitors to choose the wanted species and individual, see its location in the park and access the information sheet of the species. The monitoring guide to help volunteers in the field is included in the monitoring sheets, with 2 introductory chapters. The first chapter explains the project, while the second

explains the necessary steps to follow when monitoring a plant species. Finally, the website should contain the “Serralves em Flora” database, where the volunteers can register the observed data, and a control system for the data and photos submitted, so that only the data that is accurate can be used for studies.

3.10. Data

a) Documentation

The **data documentation** (metadata) should be stored on the website “Biodiversidade e Ambiente”, on the database of “Serralves em Flora”. The volunteer should create an account on the website if he/she wishes to register the collected data on the database, this way connecting his profile name with the data that he/she collects and stores for the project.

To data storage each document has 22 tabs, one for each of the 22 species. Each tab possesses several tables, each one corresponding to each individual that the species comprises. Each table possesses the exemplar number of the species individual, the identification number (ID) of the individual that is the number that Serralves used to register it on the database, the BBCH code and new code (Table 4) of the phenophases, the year, day of the month and the day of the year when phenophases were occurring during observation. Table 5 is an example of the table of the data documentation (the original ones are in Portuguese).

Table 5 – Example of the data documentation table. (ID – identification number; BBCH code – worldwide code number for the phenological development stages of plants)

Exemplar 1					
ID	BBCH code	New code	Year	Day (of the month)	Day (of the year)
2439	60	FO - 1	2015	21/03	113

It is expected that volunteers register their own collected data on the website in the future but, until the website database is finished, the data will be registered by the staff of Serralves with the observations recorded and delivered by the volunteers.

b) Quality Control

For volunteers who do not have experience in the phenological monitoring area, collecting accurate data at first try can be difficult, so **data quality control** is required. In some projects [4], the first year data from new volunteers is ignored and not used for the studies, since there is a high probability of that data being incorrect. That is a

possible way to deal with the problem, but there are other ways that do not waste so many data collected. For the case study of “Serralves em Flora” the **data quality control** would be made by training sessions carried out by technicians of Serralves and through the analysis of the photos taken during observations. The volunteers would be encouraged to participate in some events of the park that would allow them to monitor the species with some professional help like the “Serralves BioBlitz”. The website would also contain essential information to help volunteers getting started and there would also be a control system on the website to analyse the data collected, like event register date analyses, to see if the phenophase is occurring inside the correct expected interval.

The photos that are going to be sent with the data must also meet some requisites to be accepted. It is important that each photo meets a size and focus requisites. The size must be universal for all kind of photos, so that it can be sent to the database without problems and without taking up too much space. It is also important that the size allows to clearly see the picture of the photo, which is important for data control. For the focus, it is important that each photo focuses the phenophase that is supposed to show (for example, if the phenophase is first flower bloom, the photo should focus a completely bloom flower). These photos will be used not only to validate the data quality but also to share with others on the website to show how the phenophases of the plant should look like.

Moreover, quality control is also achieved through a phenological monitoring guide that was created, in Portuguese, for the staff of Serralves to help them understand and participate in this project (Appendix IX). This will allow the continuation of the project over the years, even if the staff of the park changes.

c) Process and Publication

At last, after the data is collected and validated, it is time to **process those data**. This final phase is when all data collected, analysed through quality control and accepted, is all gathered and phenological trends of each species are analysed and represented.

A statistical analysis will be used to **process** the collected data over time, allowing to detect eventual variations on the phenophase dates over the years [44, 45].

The dates used to calculate the means for each phenophase each year on the statistical analysis are the dates presented in the “Day (of the year)” column on Table 5.

In the first year, an ANOVA test will be used for statistical analysis and the final data is placed on a bivariate graphic (time vs. date of phenophase) that will show the changes that occur over the years on the dates of the phenophases for each studied plant. For each plant species’ phenophase, a different graph should be created. This way, it will be possible to infer the effect of climate change on each stage of the plant cycle and contribute with data to other European platforms. Serralves will contribute to the PEP725 and USA-NPN platforms, since partnerships were established with them [3, 4, 6, 9, 10, 12 - 14, 19, 29].

For the first 2 years of collected data, a *t*-test should be use to compare the means of each species observed phenophase in these 2 years for each phenophase. The species means would be calculated using specific statistical software. The confidence level will be set to 95%.

An example of the use of the *t*-test, is presented on Table 6 , with the data collected from the “Serralves BioBlitz” and additional fictional data for the species *Ilex aquifolium*.

Table 6 - Example of a t-test table for data analysis. (E = 10^^X)

***Ilex aquifolium* t-test**		
Phenophase: End of flowering (FR – 1)		
Observation Years	Mean	*P* value
2015	114	1,73E-19
2016	112	

For 3 or more years of collected data, an ANOVA test is required. The species means would be calculated using specific statistical software. The confidence level will be set to 95%. An example of the use of the ANOVA is presented on Table 7, with the data collected from the “Serralves BioBlitz” and additional fictional data for the species *Ilex aquifolium*.

Table 7 - Example of an ANOVA test table for the data analysis. (E = 10^^X)

***Ilex aquifolium* ANOVA test**		
Phenophase: End of flowering (FR – 1)		
Observation Years	Mean	*P* value
2015	114	3,51E-23
2016	112	
2017	111	

The final results would be **published** on the website to allow the public to have readily access to them [3, 9, 10, 12 - 14, 29].

In order to have monitoring results presented in graphics showing any significant phenological change, it is necessary that the monitoring program continues over the years. For this to happen, it is necessary that volunteers participate, that new people to become new volunteers, that citizen science programs continue to exist and to inform the citizens about environmental changes and what they can do to help [4, 9, 10, 12 - 14, 19, 25 – 28].

3.11. “Serralves BioBlitz” tests

On April 24th and 25th the “Serralves BioBlitz” event for the public was used as an opportunity to test the monitoring sheets for 3 of the 22 species: *Ilex aquifolium* (holly), *Quercus robur* (English oak) and *Viburnum tinus* (laurustinus).

The monitoring sheets of these 3 species were aesthetical altered in the form of a small notebook, so that people could carry it around and use it more easily (Appendix XI). In the end of “Serralves BioBlitz”, 21 notebooks of “Serralves em Flora” monitoring sheets were delivered by the visitors and the number of observations per notebook for the *Ilex aquifolium, Quercus robur* and *Viburnum tinus* were 17, 2 and 11 respectively. With the results obtained in this pilot test it was possible to detect the difficulties that the visitors had when they monitored the selected species.

The major difficulties resided on the **First flowers open** and the **First ripe fruits** phenophases. Based on these, evidences some modifications were made on the description of these phenophases in the monitoring sheets, to avoid misunderstandings on future observations.

Another problem pointed by some visitors was the existing number of exemplars per species to observe. Two of the selected species (*Ilex aquifolium and Viburnum tinus*) possessed 5 exemplars, while the remaining one possessed 3 exemplars. For some visitors, 5 exemplars to observe proved to be a tiring activity, leading to their lack of interest on plant monitoring over some time.

The “Serralves BioBlitz” collected data was stored in an excel document and can be found on the Appendix XII.

The quality control of this test phase was made by creating a control monitoring sheet for the 3 species. On the day before the event (the 23th of April), each species

was monitored and these results were compared to the ones obtained by the visitors. Also, the responsible team for this activity on “Serralves BioBlitz” followed the visitors to the observations sites, providing an explanation of the activity, and demonstrating the procedure.

IV. Discussion

1. Discussion of the existing programs meta-analysis

As presented in the results section, most topics of the survey were not present nor mentioned on the programs, publications and articles, leading to a significant lack of valuable information on the design of the monitoring programs. However, we discuss the information gathered, which led us to draw some conclusions with potentially relevant implications for future actions in this scope.

1.1. Major results of the 9 methodological steps

For the **direct observation and registration method** the use of a digital camera is not mandatory (Figure 2), but it can still be a helping tool for volunteers as well for the technicians, since it can be used as a quality control tool, that determines if the volunteer can, or cannot, collect accurate data, and also as a data registration tool, that allows the data to be registered and easily stored for a long time and still be consulted in the future.

The **study area selection** is not limited by the programs, since they intend to gather data from the biggest possible number of sites to have a global phenological tendency. Overall, the volunteer is free to select a study area that he/she sees fit, as long as the GPS coordinates are correctly inserted on to the program database, so that the new site can then be considered a possible study area for phenological monitoring.

The **selected phenophases** from the programs associated two components: (1) BBCH code - allowing an easier information exchange of collected data between programs, which creates a global database quicker; (2) identification rate of the phenophases - consisting in selecting phenophases that are easily identified to help volunteers in their observations, which leads to a bigger amount of accurate data gathered.

The BBCH lists names and definitions use many terms that most people are not familiar with, so the **denominations and definition of phenophases** is frequently altered by the programs to a more common language so that their volunteers can more easily understand it. Each program makes the changes to the designation of the phenophases that are considered fit according to the profile of the involved volunteers and the species that the program monitors.

To **select a species** to be monitored, programs frequently use the morphological features criteria (Figure 3), since it not only determines the species with more visible

and easily detectable phenophases for volunteers, reducing the amount of data errors, but also determines the frequency of representation of the species in the study area (Figure 3). This allows to select the minimum number of individuals to observe (Figure 7) and the ideal number of replicas to monitor for each species (Figure 4), even if each species possesses a different ideal number (Figure 5), in order to collect data with a more scientific character.

The type of **monitoring sheets** to use in the programs varies depending on the information of interest, since some programs only ask for data entries in dates of occurring phenophases (data less collected) while other programs are also interested in the absence dates of phenophases (data more collected), and in the observation frequency, which can vary depending if the volunteer wishes to make regular observations (frequent visits to the study area) or only single ones (single visit to the study area).

The **observation frequency** depends on the connection between the type of observation that the volunteer makes (regular or single) and the seasons of the year. The standard observation frequency is weekly-based (Figure 8), since it is enough to analyse the species and determine if a phenophase is occurring, or about to occur, in a short/long period of time. In seasons of great change for plants (spring and autumn), regular reports are necessary, leading to a daily observation frequency so that the phenophase occurrence is not lost. In seasons with less changes (summer and winter), singular reports are used and the weekly visit can turn into a monthly one since the changes are more unlikely and slow. Either way, it is still the volunteer that decides the observation frequency since he/she is the one that must match his/her life schedule with the monitoring one [7, 9, 10, 14].

The monitoring **websites** are created by the programs to allow the public to obtain (1) observation tools required to autonomously monitor plant species in different study areas, (2) information about phenological terms, definitions, objectives and projects, so that volunteers can understand the importance of the work they are doing, and (3) access the database of the collected and treated data, which scientists studying climate change and plant phenology can use in their works.

Several fields are used on the **data documentation** that must be provided by the volunteer, which are common among phenological programs so that the input data can be rearranged and found more easily on the database and traded as straightforwardly as possible among programs. The account on the website is also a requirement if volunteers want to submit data on the database, and it is a means of **quality control**

that programs created to determine if the volunteer can, or cannot, collect accurate data by himself/herself by comparing his/her data with other data (accurate) from the same area. The other technique used to control data (Figure 9), are the observation guides, since they were created by the programs for the species of interest with all observation techniques that volunteers should follow and having in mind to any study area. Another technique used are the training sessions, which allow volunteers to get acquainted with the theory of phenological monitoring and learn how to proceed correctly on the field (Figure 10), so they, in the future, can monitor autonomously the species selected for the study and obtain precise phenological data.

The **statistical analysis** of the data that passed the quality control tests is necessary to determine the changes in plant phenology over time. To reduce the amount of good data loss, all data collected from all species, (even the ones with different number of replicas) is used (Figure 11), therefore decreasing the amount of errors that appear on the statistical tests.

2. Discussion of the design of “Serralves em Flora”

“Serralves em Flora” is a citizen science phenological project specifically developed for Serralves Park and uses the existing information that was found during research about this topic and the meta-analysis of the existing monitoring programs previously discussed. Although we based some of the decisions on options of other programs, some difficulties were encountered resulting from the lack of information on the programs. Despite these difficulties, “Serralves em Flora” project was developed and tested in several moments, namely during a 2-day event in 2015 involving the public that usually visits the Serralves Park.

This chapter presents the discussion of the main accomplishments achieved and the main difficulties encountered during the creation, development and testing of the “Serralves em Flora” project.

2.1. Main accomplishments

The **partnerships** established with the PEP725 [13] and the USA-NPN [14] programs in the starting phase of the project development were determinant for the rest of the project design. Both programs shared important information (phenological

guides, phenophase selection list, BBCH list, observation reports…) that were used on the adaptation of the 9 methodological steps for the “Serralves em Flora” project [3, 5 – 8, 13, 14, 16]. Using information from both programs, especially regarding the data registration (which data to observe and how to collect it), we were able to simplify the process of data sharing between different programs in the future [2].

The **species selection** criteria created and applied for Serralves Park allowed to select, from the 201 taxa (species and varieties) present in the Park, 18 taxa which fulfilled all criteria established for the “Serralves em Flora” project. The criteria used can be applied on other locations and projects, since most of the information required for each species can be found on the internet, with the exception of the number of exemplars with the same characteristics (age, growing rate, physical appearance…) on the same area. The criteria used for species selection contemplated different decisive factors that combined the volunteer’s ability to detect the species and its phenophases (which it is associated with the “present structures and visibility” and the “individual proximity and access” criteria) and the scientific rigor of the project (which includes “life form”, “origins” and the “number of exemplars” criteria).

The final 22 species list include 4 species (*Buxus sempervirens*, *Laurus nobilis*, *Quercus robur* and *Taxus baccata*) that did not fulfil all the crucial criteria (life form, origins, present structures and visibility, number of individuals and individual proximity and access), but which were still selected to be include in “Serralves em Flora” using another criterion: their emblematic presence in Portugal and Serralves Park.

Selected phenophase and specific phenophase definitions and images were created and added for each one of the 22 species (Appendix VIII), so that the 4 species that did not possess all crucial criteria could still be monitored in the same way as the remaining 18.

The **“Serralves BioBlitz”** event allowed to test, with heterogeneous public (scholar and general public), the choices made for the “Serralves em Flora” project, more precisely the observation method selected, the selected phenophases, the name and definition adaptation of the phenophases, the monitoring sheets and some techniques for the data quality control.

The method of **direct observation and registration** proved to be adequate for the activity, since the visitors had access to the materials required (the monitoring notebooks) and understood quite easily the way to observe and to register the information. The material was portable and printed, so transporting it around the park

did not present any problem for the visitors either. Since the event was a phase test of the project (phase test 2) the visitors were not informed about the requirement of the camera to photograph the phenophases, so this part of the developed method was not tested yet. It is expected that all the materials required for this project are available on the “Serralves em Flora” website when this project is fully operational.

The **selected phenophases** were easily identified by the visitors thanks to the new and adapted **names and definitions. The only exceptions** that led to some confusion and incorrect identification, were “first flowers open” and the “first ripe fruits”, resulting of the original definition presented, which was not explicit enough. This test showed that, even though the new denomination and definition were carefully thought to reduce the possible confusion of volunteers, new adjustments were still needed for this 2 phenophases.

Nevertheless, and since this was the first test with the general public, the results were positive, since errors only appear in 2 of the 13 tested phenophases in this event. Also, the visitors that listened to the previous explanation about the activity committed less errors in these 2 phenophases than others. This shows that a proper formation session can serve as an instruction and **quality control** tool. The control monitoring sheet was the other quality control tool used and, when comparing the results of the control with the rest, it was possible to confirm the major data errors on the 2 mentioned phenophases and the amount of groups that made this mistake, since not all results were from the groups that were accompanied by the project responsible.

Some of the **monitoring sheets** notebooks were received from visitors that did the monitoring activity autonomously, showing that the monitoring sheets design and information achieved the established purposes: motivated public participation and allowed for the volunteers to monitor plant species independently. Now, after the correction of the 2 problematic phenophase definitions, it is expected that volunteers collect the data autonomously with even less errors.

The **data storage** file actual design allows to store the data for the 22 species selected over the years, but whenever the database of the “Serralves em Flora” website is finished, the design will change so that volunteers can store their data more easily. The volunteers would store their data using the registration table phenophase code and colour present on the monitoring sheets as a guide on the database. The monitoring sheets used on the “Serralves BioBlitz” did not possess colours associated with the phenophases codes, since the data results would be stored by the person in charge of the coordination of the activity and not the volunteers, but if the volunteers

understood the registration table division for each phase group (FO, FL, FR, SE, CO) then the use of colour would make the division easier to submit the data, matching the monitoring sheet colours with the ones on the website storage.

2.2. Main difficulties

One of the main difficulties encountered during this work was the **contact with the other phenological programs**. The partnerships were established with 2 of them [13, 14], but getting in touch with them or with the other programs was a challenge. Some programs never replied some of the requests or questions that were sent and others took too long to reply. Sometimes, the answers were not helpful for our work.

The **phenophase selection** for “Serralves em Flora” also presented quite a challenge, as well as the **new denomination and definition**. All programs followed the BBCH list, which possessed a code and a name for each phenophase, as well as a small definition that, most of the times, was vague enough to lead to confusion. Although they used the same list, each program selected the phenophases that they saw fit for each of their selected species and created a name and definition different from the other programs [9, 10, 2 - 14].

Aside from these factors, **the language differences** also complicated the denomination and the definition of the phenophases. Since the project is for Portugal and Portuguese public, it was logical that the monitoring sheets should be written in Portuguese. This required that the phenophases new names and definition were translated to Portuguese, but in a way that the translation did not alter the true concept of the chosen phenophases. The selection of the phenophases, their new names and definitions was a demanding process, since they had to be adequate for each species that followed the BBCH list, similar to the ones selected by the programs, especially the PEP725, because of the established partnership so “Serralves em Flora” becomes a European program.

Another difficulty resided on the **species selection phase**, more precisely on the exemplars to monitor for each species. In Serralves Park, the species that only grow in one area of the park were easy to select the exemplars that were similar, but for the species that could grow in several areas of the park it was more difficult to establish the ideal exemplars for the study. Since the exemplars needed to be close to each other, although there are no records of the distances (minimum, ideal and maximum) that they must have, so that they could all suffer the same ecological conditions (shade,

temperature…) and have similar morphological characteristics (size, shape…), the accomplishment of these conditions implied a lot of search to find exemplars for each taxa. There were several rejections and visits to Serralves Park before selecting the final exemplars for the final 22 species.

The **monitoring sheets** were altered several times before deciding the final design. The type of monitoring sheet to use based on the ones found [9, 10, 12, 14] was decided without any problems, but the adaptation of the selected style for the “Serralves em Flora” project created several difficulties on the monitoring sheet development. The registration table was the sheet component that most changes suffered during this work, since the information presented needed to be simple to understand and use, while being informative and correct. The monitoring sheet size also needed to be considered to allow volunteers to easily carry and use it, so the information distribution was rearranged several times to fulfil that requisite.

The programs presented information on the documentation, quality control and publication of their data, but for the **statistical analysis** some of the necessary information was lacking, which led to some difficulties for our work. The type of tests suitable to apply to this kind of data were already proposed, since they were mentioned in other programs, but information of the type of data to use and the way to input data were the main uncertainties, since the information regarding this topic on articles was not developed enough (some works only mentioned the test used and the results, others only showed the graphics and the remaining information was not mentioned at all) [19, 29].

V. Conclusion

This work collected a vast amount of information about scientific phenology monitoring works and citizen science phenological programs and merged the most important contents of each area to originate the “Serralves em Flora” project. Although there were some difficulties in collecting and selecting some information, this project thrived and developed and was ultimately tested as a monitoring program with the Serralves Park’s public.

“Serralves em Flora” was developed for Serralves Park using the existing programs as base, but the material selected and created (monitoring sheets, species selection criteria…) can still be adapted for other study areas that the public may be interested in studying.

The structure established for the monitoring sheets proved to be useful, with the “Serralves BioBlitz” volunteers being able to monitor phenophases autonomously. Now, with the last alterations made on the phenophase definitions, it is expected that volunteers can collect correct data for each phenophase more easily and frequently.

“Serralves em Flora” still presents some incomplete components, related to the website, database and digital camera, which must be finished before becoming official in the Serralves Park activities:

- the website of the project is not finished yet, neither is the final database, so no test was made to see if the volunteers could use it properly to (1) deposit the collected data, (2) consult information about the project and (3) download the monitoring support materials and guides;
- until now no test of the use of digital camera in “Serralves em Flora” was made by the volunteers since, in the “Serralves BioBlitz” event, the guidelines and formats for the image databasing were not established by Serralves.

The work made for “Serralves em Flora” project allowed the creation of a paper to be submitted to the scientific journal BioScience (Appendix XIII).

Finally, when all project components are finished, it is expected that “Serralves em Flora” is officially integrated in Serralves Parks programme and that the visitors contribute to the data collection over time. This way, the climate change impact in the Park’s flora can be studied and the results can be shared with the partner programs in Europe and USA.

VI. References

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VII. Appendixes

Appendix I – Bibliographic research and information on phenology monitoring projects.

Articles/Books	Information	Source	Classification	References	Nº of individuals
"A new herbarium-based method for reconstructing the phenology of plant species across large areas"	Monitoring; phenology; climatic change; study of herbaceous plants; contrast between urban and rural areas in terms of phenological changes.	http://www.amjbot.org/content/93/4/512.full.pdf	2	Lavoie, C. and Lachance, D. (2006). A New Herbarium-Based Method for Reconstructing the Phenology of Plant Species across Large Areas. *American Journal of Botany.* **93**: 512-516.	N/A
"Biodiversity and trace element content of epiphytic bryophytes in urban and extraurban sites of southern Italy"	Effect of pollution on flora.	http://link.springer.com/article/10.1023%2FB%3AVEGE.0000019025.36121.5d	2	Giordano, S., Sorbo, S., Adamo, P., Basile, A., Spagnuolo, V. and Cobianchi, R.C. (2003). Biodiversity and Trace Element Content of Epiphytic Bryophytes in Urban and Extraurban Sites of Southern Italy. *Plant Ecology.* **170**: 1-14.	10; 3
"The role of botanical gardens in climate change research"	Specialized garden to phenology, climate change, effects of climate change on flora, photography.	http://onlinelibrary.wiley.com/doi/10.1111/j.1469-8137.2009.02800.x/abstract	3	Primack, R.B. and Miller-Rushing, A.J. (2009). The role of botanical gardens in climate change research. *New Phytologist*. **182**: 303-313.	97
"Changes in the functional composition of a Central European urban flora over three centuries"	Changes in urban land flora over the years.	http://www.ufz.de/export/data/1/22511_Knapp_et_al_PPEES_2010.pdf	1	Knapp, S., Kuhn, I., Stolle, J., Klotz, S. (2010). Changes in the functional composition of a Central European urban flora over three centuries. *Perspectives in Plant Ecology, Evolution and Systematics*. **12**: 235-244	N/A
"Changes in Vascular Plant Biodiversity in the Netherlands in the 20th Century Explained by	Climate change, phenology, relationship between climate change and flora.	http://link.springer.com/article/10.1007%2Fs10584-005-5287-7	3	Tamis, W.L.M., Zelfde, M.V.,Meijden, R.V.D., Haes, H.A.U. (2005). Changes in Vascular Plant Biodiversity in the Netherlands in the 20th Century Explained by their Climatic and other	N/A

N/A – information not available

their Climatic and other Environmental Characteristics"				Environmental Characteristics. *Climate Change*. **72**: 37-56	
"THE GLOBAL PHENOLOGICAL MONITORING CONCEPT - Towards International Standardization of Phenological Networks "	Climatic changes, phenology, purpose of the study of phenology, GPM network, selection of species, phenological gardens, observation, phenophases, and partnerships.	http://kab.agrobiologie.cz/natural/GPM_Concept.pdf	4	Bruns, E., Chmielewski, F.M., VanVliet, A.J.H. (2003). The Global Phenological Monitoring Concept-Towards International Standardization of Phenological Networks. *Phenology: An Integrative Enviromental Science*. **39**: 93-104.	1
"Growth stages of mono-and dicotyledonous plants" (BBCH Monograph)	BBCH code: definition, scale, organization, states, tables with type plants, states and BBCH code.	http://www.jki.bund.de/fileadmin/dam_uploads/_veroeff/bbch/BBCH-Skala_englisch.pdf	2	Meier, U. (2001). *Growth stages of mono-and dicotyledonous plants - BBCH Monograph.* 2ª Edição, Federal Biological Research Centre for Agriculture and Forestry. Berlin.	N/A
"Impacts of climate change on the future of biodiversity"	Impact of changes in populations and communities.	http://onlinelibrary.wiley.com/doi/10.1111/j.1461-0248.2011.01736.x/pdf	1	Bellard, C., Bertelsmeier, C., Leadley, P., Thuiller, W. and Courchamp, F. (2012). Impacts of climate change on the future of biodiversity. *Ecology Letters*. **15**: 365-377	N/A
"Long-Term Detection of Global Vegetation Phenology from Satellite Instruments "	Phenology, climate change, monitoring method.	http://cdn.intechopen.com/pdfs-wm/32935.pdf	4	Zhang, X., Friedl, M.A., Tan, B., Goldberg, M.D. and Yu, Y. (2012). *Long-Term Detection of Global Vegetation Phenology from Satellite Instruments*. Phenology and Climate Change.	N/A
"Monitoring Plant Phenology Using Digital Repeat Photography"	Phenology, monitoring, repeated shooting method, climate change, methods comparison monitoring.	http://link.springer.com/article/10.1007%2Fs00267-008-9086-6	5	Crimmins, M.A., Crimmins, T.M. (2008). Monitoring Plant Phenology Using Digital Repeat Photography. *Environmental Management*. **41:** 949-958	N/A
"Novel urban ecosystems, biodiversity, and conservation"	Response of biodiversity to urbanization, conservation of species, temperature in phenology.	http://www.sciencedirect.com/science/article/pii/S0269749111000960	1	Kowarik, I. (2011). Novel urban ecosystems, biodiversity, and conservation. *Environmental Pollution*. **159**: 1974-1983.	N/A
"Phenological	Climate change, phenology,	http://files.urbanlandscapelab.or	4	Luo, Z., Sun, O.J., Ge, Q., Xu, W., Zheng, J. (2007).	10;20

N/A – information not available

responses of plants to climate change in an urban environment"	phenophases, relationship between phenology and urban environment, temperature in phenology, data.	g/safari7/BeijingSafari4/Research/Articles/urban%20heat:plants%20and%20climate%20change.pdf		Phenological responses of plants to climate change in an urban environment. *Ecological Research* **22**: 507-514.	
"From Caprio’s lilacs to the USA National Phenology Network "	Consequences of climatic changes in phenology, phenology changes in organisms, continuous study of phenology, history of phenology in USA, NPN, phenological monitoring and other environmental variables.	http://wwwpaztcn.wr.usgs.gov/julio_pdf/Schwartz_et_al-NPN-2012.pdf	4	Schwartz, M.D., Betancourt, J.L. and Weltzin, J.F. (2012). From Caprio's lilacs to the USA National Phenology Network. *Frontiers in Ecology and the Environment* **10**: 324–327	N/A
"Springtime in the city: exotic shrubs promote earlier greenup in urban forests"	Phenology, climate change, phenology in urban, spring environment, comparison between urban and rural phenology, phenophases, temperature.	http://link.springer.com/article/10.1007%2Fs10530-008-9343-x#page-1	3	Shustack, D.P., Rodewald, A.D. and Waite, T.A. (2009). Springtime in the city: exotic shrubs promote earlier greenup in urban forests. *Biological Invasions*. **11**: 1357-1371.	10; 7
"The footprint of urban climates on vegetation phenology"	Phenology, climatic changes, phenology in the cities, satellite monitoring, comparison between the city and rural environment in phenology.	http://onlinelibrary.wiley.com/doi/10.1029/2004GL020137/pdf	3	Zhang, X., Friedl, M.A., Schaaf, C.B., Strahler, A.H., Schneider, A. (2004). The Footprint of Urban Climates on Vegetation Phenology. *Geophysical Research Letters*. **31**. L12209	N/A
"The impact of climate change on cherry trees and other species in Japan"	Phenology, climate change, temperature in phenology, phenology in cities, response to climatic changes.	http://people.bu.edu/primack/primack_etal_cherries09.pdf	4	Primack, R.B., Higuchi, H., Miller-Rushing, A.J. (2009). The Impact of Climate Change on Cherry Trees and Other Species in Japan. *Biological Conservation*. **142**: 1934-1949.	10
"Urban biodiversity in local newspapers: a historical perspective"	Changes in biodiversity over time with urbanization, conservation of species, phenological studies to the fauna.	http://link.springer.com/article/10.1023%2FA%3A1012099420443#page-1	1	Vuorisalo, T., Lahtinen, R. and Laaksonen, H. (2000). Urban Biodiversity in Local Newspapers: A Historical Perspective. *Biodiversity and Conservation*. **10**: 1739–1756.	N/A
"Citizen Science: Can Volunteers Do Real Research?"	Citizen science, advantage of volunteers, data quality control, selection of data to be collected.	http://bioscience.oxfordjournals.org/content/58/3/192.abstract	5	Cohn, J.P. (2008). Citizen Science: Can Volunteers Do Real Research? *BioScience*. **58**: 192-197.	N/A
"Phenology and Citizen Science - Volunteers have documented	Citizen science, advantage of citizen science programs, websites, volunteer training, quality of data.	http://bioscience.oxfordjournals.org/content/60/3/172.short	5	Mayer, A. (2010). Phenology and Citizen Science - Volunteers have documented seasonal events for more than a century, and scientific studies are	1

N/A – information not available

seasonal events for more than a century, and scientific studies are benefiting from the data"				benefiting from the data. *BioScience*. **60**: 172-175.	
"Scientific knowledge and attitude change: The impact of a citizen science project"	Citizen science, the objectives of citizen science programs, studies made in voluntary programs to assess them and acquired knowledge.	http://www.tandfonline.com/doi/abs/10.1080/.U80UGeNdWSo#.VClgnPldVV4	5	Brossard, D., Lewenstein, B. and Bonney, R. (2005). Scientific knowledge and attitude change: The impact of a citizen science project. *International Journal of Science Education*. **27**: 1099-1121.	N/A
"Citizen Science as an Ecological Research Tool: Challenges and Benefits"	Citizen science benefits, phenological monitoring, difficulties, control of the data.	http://www.annualreviews.org/doi/abs/10.1146/annurev-ecolsys-102209-144636	5	Dickinson, J.L., Zuckerberg, B. and Bonter, D.N. (2010). Citizen Science as an Ecological Research Tool: Challenges and Benefits. *Annual Review of Ecology, Evolution, and Systematics*. **41**: 149-172.	N/A
"Standardized phenology monitoring methods to track plant and animal activity for science and resource management applications"	Phenology, monitoring, monitoring methods for plants and animals, monitoring records, creating monitoring methods, photography.	http://link.springer.com/article/10.1007%2Fs00484-014-0789-5#page-1	5	Denny, E.G., Gerst, K.L, Miller-Rushing, A.J., Tierney, G.L., Crimmins, T.M., Enquist, C.A.F., Guertin, P., Rosemartin, A.H., Schwartz, M.D., Thomas, K.A. and Weltzin, J.F. (2014). Standardized phenology monitoring methods to track plant and animal activity for science and resource management. *International Journal of Biometeorology*. **58**: 591-601.	1
"MEASURING & MONITORING - Plant Populations"	Plant labelling methods for monitoring programs.	http://www.blm.gov/nstc/library/pdf/MeasAndMon.pdf	5	Elzinga, C.L., Salzer, D.W. and Willoughby, J.W. (1998). *Measuring and monitoring plant population*. U.S. Bureau of Land Management Papers. Colorado	———
“HÁ VIDA NO PARQUE! - Paisagem e Biodiversidade em Serralves"	Park design (slope, sun exposure, geology, water); zonation of the park and mapping; areas of the park.	———	5	Almeira, J.M., Alves, E., Nogueira, P., Ribeiro, R. and Viegas, S. (2014). *Há Vida no Parque: paisagem e biodiversidade em serralves*. 1ª Edição, Fundação de Serralves. Porto.	———
"PARQUE DE SERRALVES - Paisagem	History of construction and change of ownership of the park; flora and	———	5	Nogueira, P., Almeida, J., Ribeiro, R., Oliveira, A., Almeida, J.M., Viegas, S. and Alves, E. (2013).	———

N/A – information not available

com vida"	fauna of the park; Park events.			*Parque de Serralves: paisagem com vida*. 1º Edição, Fundação de Serralves. Porto.	
"UMA VISITA A SERRALVES"	Park areas and characterization.	_____	5	Nogueira, P., Almeida, J. and Almeida, M. (2013). *Uma visita a Serralves*. 1ª Edição, Fundação de Serralves. Porto.	_____
"Plano de Recuperação da Paisagem de Serralves: caracterização e diagnose"	Park areas and characterization.	_____	5	Mateus, J. (2002). *Plano de Recuperação da Paisagem de Serralves: caracterização e diagnose*. Fundação de Serralves. Porto.	_____
"Portugal - o Mediterrâneo e o Atlântico"	Portugal climate characterization.	_____	5	Ribeiro, O. (1993). *Portugal: o Mediterrâneo e o Atlântico*. 1ª Edição, Edições João Sá da Costa, LDA. Lisboa.	_____
"Morfologia e Biodiversidade nos Espaços Verdes da Cidade do Porto - Livro 1: Selecção das áreas de estudo"	Climate of Oporto.	http://bio-diver-city.fc.up.pt/index.php/book-i-selection-of-the-study-areas-portuguese-2nd-edition	5	Marques, P.F., Fernandes, C., Lameiras, J.M., Guilherme, F., Silva, s. and Leal, I. (2014). *Morfologia e Biodiversidade nos Espaços Verdes da Cidade do Porto - Livro 1: Selecção das áreas de estudo.* 2ª Edição, CIBIO |Centro de Investigação em Biodiversidade e Recursos Genéticos. Porto.	_____
"Ecological Applications of Multilevel Analysis of Variance"	ANOVA statistical analysis.	http://www.esajournals.org/doi/abs/10.1890/06-2041.1	4	Qian, S.S. and Shen, Z. (2007). Ecological Applications of Multilevel Analysis of Variance. *Ecology*. **88**: *2489-2495.*	_____
"Statistics and the Scientific Method in Ecology"	ANOVA statistical analysis.	http://www.ericlwalters.org/Bayes.pdf	4	Dennis, B. (2004). Statistics and the Scientific Method in Ecology. *The Nature of Scientific Evidence: Statistical, Philosophical and Empirical Considerations*. pp: 327-378.	_____

Sites	Information	Source	Classification	References
flora.on	List of plant present in Portugal.	http://www.flora-on.pt/	4	Date of access: 19/02/2015, in http://www.flora-on.pt/
Flora ibérica	List of plant species recorded	http://www.floraiberica.es/in	4	Date of access: 19/02/2015, in http://www.floraiberica.es/index.php

N/A – information not available

	throughout the Iberian Peninsula and the Balearic Islands.	dex.php		
Wildflowercenter	List of native plant species of North and Central America.	http://www.wildflower.org/	4	Date of access: 19/02/2015, in http://www.wildflower.org/
NSW FloraOnline	List of species of plants present in New South Wales.	http://plantnet.rbgsyd.nsw.gov.au/	3	Date of access: 19/02/2015, in http://plantnet.rbgsyd.nsw.gov.au/
Japanese Treeflower	List of flowering plants of species in Japan.	http://treeflower.la.coocan.jp/	3	Date of access: 19/02/2015, in http://treeflower.la.coocan.jp/
Royal Horticultural Society	List of existing plant species in the UK garden.	http://www.rhs.org.uk/Plants	4	Date of access: 19/02/2015, in http://www.rhs.org.uk/Plants
Jardineiro.net	List of plant species that exist worldwide.	http://www.jardineiro.net/	3	Date of access: 19/02/2015, in http://www.jardineiro.net/
Florestar.net	Information on various plants. Photographs of several phenophases	http://www.florestar.net/	5	Date of access: 19/02/2015, in http://www.florestar.net/
Wikimedia Commons	Photographs of several phenophases of several species	https://commons.wikimedia.org/wiki/Main_Page	5	Date of access: 22/02/2015, https://commons.wikimedia.org/wiki/Main_Page
Serralves Flora database	Photographs of several phenophases of several species. Location and information of the park's flora	http://serralves.ubiprism.pt/flora/map	5	Date of access: 4/03/2015, http://serralves.ubiprism.pt/flora/map
Tree Names	Photographs of several phenophases of several species	http://www.treenames.net/index.html	5	Date of access: 5/03/2015, http://www.treenames.net/index.html
pixabay	Photographs of several phenophases of several species	https://pixabay.com/	5	Date of access: 5/03/2015, https://pixabay.com/
imgarcade.com	Photographs of several phenophases of several species	http://imgarcade.com/	5	Date of access: 5/03/2015, http://imgarcade.com/
PLANTAR ÁRBOLES y arbustos	Photographs of several phenophases of several species	http://plantararboles.blogspot.pt/2012/09/arbustosautoctonos-espana.html	5	Date of access: 5/03/2015, http://plantararboles.blogspot.pt/2012/09/arbustosautoctonos-espana.html
wellywoman ~ A Life in Wellies	Photographs of several phenophases of several species	https://wellywoman.wordpress.com/	5	Date of access: 5/03/2015, https://wellywoman.wordpress.com/

N/A – information not available

Landscape Plant Recognition	Photographs of several phenophases of several species	http://courses.washington.edu/ehuf331/Plant_Pages_subfolders/BUXACEAE.shtml	5	Date of access: 5/03/2015, http://courses.washington.edu/ehuf331/Plant_Pages_subfolders/BUXACEAE.shtml
Pacific Horticulture	Photographs of several phenophases of several species	http://www.pacifichorticulture.org/	5	Date of access: 5/03/2015, http://www.pacifichorticulture.org/
Plinth et al. - between art & horticulture	Photographs of several phenophases of several species	http://plinthetal.com/	5	Date of access: 5/03/2015, http://plinthetal.com/
UBC Botanical Garden and Centre for Plant Research	Photographs of several phenophases of several species	http://www.botanicalgarden.ubc.ca/	5	Date of access: 5/03/2015, http://www.botanicalgarden.ubc.ca/
majestic trees	Photographs of several phenophases of several species	http://www.majestictrees.co.uk/	5	Date of access: 5/03/2015, http://www.majestictrees.co.uk/
nzflora- Flora of New Zealand	Photographs of several phenophases of several species	http://www.nzflora.info/	5	Date of access: 5/03/2015, http://www.nzflora.info/
Árvores e Arbustos de Portugal	List of plant species from Portugal and its importance.	http://arvoresdeportugal.free.fr/index.htm	4	Date of access: 19/02/2015, in http://arvoresdeportugal.free.fr/index.htm
Geolearning	Flora of each climatic region.	http://geotouring.webnode.pt/	4	Date of access: 11/05/2015, in http://geotouring.webnode.pt/

Initiatives	Information	Source	Classification	References	Nº of indivíduals
Global Phenological Monitoring (GPM)	Characterization of phenological phases studied; observed plants and data on these to the public.	http://gpm.hu-berlin.de/gpm/faces/index.xhtml	3	Date of access: 19/02/2015, in http://gpm.hu-berlin.de/gpm/faces/index.xhtml	1
USA National Phenology Network (USA-NPN)	Monitoring; data collected by scientists and volunteers; educational programs for the public; scientific publications on phenology, activities that the program	https://www.usanpn.org/node/35	4	Date of access: 19/02/2015, in https://www.usanpn.org/node/35	1

N/A – information not available

	performs to the public; Nature’s notebook program.				
Nature's Calendar	Monitoring; phenology; citizen science; interaction between climate change and phenology; studied species and these data to the public; indicator plants for spring activities that the program performs to the public.	http://www.naturescalendar.org.uk/	4	Date of access: 19/02/2015, in http://www.naturescalendar.org.uk/	1
Observatoire des Saisons (ODS)	Monitoring; phenology; protocols for phenological observations; observed species and data on these activities which the program performs to the public.	http://www.obs-saisons.fr/	4	Date of access: 19/02/2015, in http://www.obs-saisons.fr/	1
Project BudBurst	Monitoring; phenology; phenological phases studied; climate change; data collected by the public; teaching about phenology to the public; monitoring sheets to phenological observations; scientific publications; activities to the public.	http://budburst.org/home	5	Date of access: 19/02/2015, inhttp://budburst.org/home	1
Pan European Phenology Project (PEP725)	Data collected by the European Union on plant phenology.	http://www.pep725.eu/index.php	5	Date of access: 19/02/2015, in http://www.pep725.eu/index.php	1
International Phenological Gardens (IPG)	Monitoring; climate impacts; phenological models; phenological phases studied.	http://www.agrar.hu-berlin.de/fakultaet/departments/dntw/agrarmet/phaenologie/ipg/ipg_allg-e	3	Date of access: 19/02/2015, in http://www.agrar.hu-berlin.de/fakultaet/departments/dntw/agrarmet/phaenologie/ipg/ipg_allg-e	N/A
PlantWatch	Citizen science program of plant monitoring.	https://www.naturewatch.ca/plantwatch/	4	Date of access: 19/02/2015, in https://www.naturewatch.ca/plantwatch/	N/A
Phenological Eyes Network (PEN)	Data collected by Japan on plant phenology; use of satellites.	http://pen.agbi.tsukuba.ac.jp/	2	Date of access: 19/02/2015, in http://pen.agbi.tsukuba.ac.jp/	N/A

N/A – information not available

Initiatives materials	Information	Source	Classification	Initiatives	References	Nº of individuals
"Plant and Animal Phenophase Definitions"	Phenophase, monitoring sheets phenophase definitions, phenophases for different types of plant.	https://www.usanpn.org/files/shared/files/USA-NPN_Phenophase_defs-report_FINAL.pdf	5	USA Natural Phenology Network (USA-NPN)	USA National Phenology Network [USA-NPN] (2013). Plant and Animal Phenophase Definitions. Report of the *USA National Phenology Network [USA-NPN]* initiative, protocol material.	1
Phenology 2012 "Future climate & the living earth: Book of abstracts"	Several short texts on various topics of phenology and climate change.	http://www4.uwm.edu/letsci/conferences/phenology2012/abstract_book.pdf	1	USA Natural Phenology Network (USA-NPN), University of Wisconsin (UWMILWAUKEE), Geographic Information Science Center of Excellence, NSF and International Society of Biometeorology	Geographic Information Science Center of Excellence, International Society of Biometeorology, NSF, USA Natural Phenology Network and University of Wisconsin (2012). Phenology 2012 - Future climate & the living earth: Book of abstracts. Report of the *Geographic Information Science Center of Excellence, International Society of Biometeorology, NSF, USA Natural Phenology Network and University of Wisconsin* initiatives, book of abstracts.	N/A
Poster da PEP725 (2012)	PEP725, phenology, collected data, users, partners, future plans.	http://www.pep725.eu/downloads/EGU_2012.pdf	1	Pan European Phenology Project (PEP725)	Koch, E., Lipa, W., Ungersbõck, M. and Zach-Hermann, S. (2012). The Pan European Phenological Database. Reports of the *Pan European Phenology Project* initiative, presentation poster. Reports of the	N/A
"Trend of earlier spring in central Europe continued"	Phenology, relationship between phenology and climate change, changes in registered phenophases.	http://www.pep725.eu/serendipity/index.php?/archives/25-Trend-of-earlier-spring-in-central-Europe-continued.html	2	Pan European Phenology Project (PEP725)	Ungersbõck, M., Jurkovic, A., Koch, E., Lipa, W., Scheifinger, H. and Zack-Hermann, S. (2013). Trend of earlier spring in central Europe continued. Reports of the *Pan European Phenology Project [PEP725]*	N/A

N/A – information not available

					initiative, presentation material.	
"Spring continues to spring earlier in central Europe"	PEP725, records of annual flowers in spring, plant changes in the spring.	http://presentations.copernicus.org/EMS2013-756_presentation.pdf	1	Pan European Phenology Project (PEP725)	Koch, E., Ungersbõck, M., Jurkovic, A., Lipa, W., Scheifinger, H. and Zach-Hermann, S. (2013). Spring continues to spring earlier in central Europe. Reports of the *Pan European Phenology Project [PEP725]* initiative, presentation material.	N/A
"Phenological Observation Guide of the International Phenological Gardens"	Phenophases used and their definitions, phenophase identification of some plants, explanation of some phenophases for specific plants.	http://www.agrar.hu-berlin.de/fakultaet-en/departments/dntw-en/agrarmet-en/phaenologie/ipg/IPG_ObsGuide.pdf/view	4	International Phenological Gardens (IPG)	International Phenological Gardens [IPG]. Phenological Observation Guide of the International Phenological Gardens (revised version from the observation guide from 1960). Reports of the *International Phenological Gardens [IPG]* initiative, protocol material.	1
"Using phenology to detect plant responses to climate and climate change"	Phenology, phenophases, phenological patterns, climatic change (global and continental), relationship between phenology and climate change, case study Common Lilac in USA, consequences of the change in phenology, case study California, NPN, monitoring sheets, definition of phenophases, phenophases of observation guide.	http://lizmatthews03.files.wordpress.com/2009/09/lavo-presentation_july-2011.pdf	5	USA Natural Phenology Network (USA-NPN); Phenology Stewardship Program (UCSB)	Mazer, S., Mathews, L. and Haggerty, B. (2011). Using phenology to detect plant responses to climate and climate change. Reports of the *USA Natural Phenology Network [USA-NPN]* and the *Phenology Stewardship Program [UCSB]* initiatives, presentation material.	1
"Guidelines for plant phenological observations"	Phenology, connection with climate change, history of phenology, application of phenology in several areas, observation guide: choice of	http://www.omm.urv.cat/documentation.html Guidelines for plant phenological observations	5	Pan European Phenology Project (PEP725)	Koch, E., Bruns, E., Chmielewski, F., Defila, C., Lipa, W. and Menzel, A.Guidelines for plant phenological observations. Reports of the *Pan European Phenology Project [PEP725]* initiative, protocol material.	1

N/A – information not available

	plants, choice of stages, site selection, choose the height and frequency, monitoring sheets, observation guide, input data, data processing, public results.					
"The Phenology Handbook: A guide to phenological monitoring for students, teachers, families, and nature enthusiasts"	Phenology, phenophases, phenology variation at different scales, history of phenology, volunteers for monitoring phenology, climate change, climate relation to phenology, networks, citizen networks, citizen science, NPN, NPN monitoring, phenological monitoring sites to monitor, time for monitoring, monitoring species, species to choose from, guide and definitions of phenophases, phenophases guide, phenological guide to the case study of California, species classification of records, monitoring records for children.	https://www.usanpn.org/files/shared/files/Haggerty_Mazer_ThePhenologyHandbook_v3Aug2009.pdf	5	USA Natural Phenology Network (USA-NPN); Phenology Stewardship Program (UCSB); Project BudBurst	Haggerty, B.P. and Mazer, S.J. (2008). The Phenology Handbook: A guide to phenological monitoring for students, teachers, families, and nature enthusiasts. Reports of the *USA Natural Phenology Network, Phenology Stewardship Program [UCSB]* and *Project BudBurst* initiatives, protocol material.	1

N/A – information not available

Appendix II – Serralves Park zones' characterization

Upper Zone

The House Gardens was designed by Jacques Gréber to be an autonomous place with a vast diversity of spaces and habitats. It is composed by different zones which are [35, 36, 38]:

- Sweetgum Tree Avenue – a tunnel of trees (78 *Liquidambar styraciflua* divided in 4 alignment of trees) that lead to the House. These trees were planted in 1930 according to the project of Gréber.
- Central Parterre – it connects the House with the Sweetgum Tree Avenue and the Lake. Since it is located on the upper zone of the park, it is formed by several platforms with different levels. On the centre of each platform there is a water path that leads to a fountain on the lower level. The flora of this place consists on some species of magnolias (like *Magnolia grandiflora* and *stellata*) and metrosideros (*Metrosideros robusta*).
- Lateral Parterre – It is a close and autonomous space, created, after 1987, as an extension of the west wing of the House, connecting her with the Sweetgum Tree Avenue and the Beech Grove. It consists in a glade composed of herbaceous mass and boxwood hedges (*Buxus sempervirens*). On the extreme west it contains rhododendrons *(Rhododendron* sp).
- Rose Garden – it consists of 2 layers where the upper one connects with de Sweetgum Tree Avenue and the lower one connects to the Museum Gardens. It's also connected to the Sundial Garden that is the place where the light appears after leaving the Rose Garden's shade. It is an important place of the park, where visitors like to stop by.
- Sundial Garden – still loyal to Gréber's design, this garden consists in a small glade with a small sundial support in the centre. It is a transition zone between the Rose Garden and the Tennis Court. It is a zone with bright light, with a yew tree structure on the periphery of the garden and a *Rhododendron arboreum.*
- Tennis Court – like the name suggests, this area was once a place for some sport activity. Nowadays this area is considered to be a meeting place and a cultural area. The tea house is located in the area, allowing visitors some tranquillity and relaxation when visiting this area of the park.

- Camellias Garden – Gréber was the one that planted the hedges of camellias in this area. In the centre there is an *Araucaria heterophylla* that already existed in the garden before 1925. To contrast the volume and colours of these camellias, some narcissus and gardenias were planted for their fragrance.
- Beech Grove – It is a shadow space, punctuated by glades, with a more natural character. The natural scenery is recreated through the irregularity of the planting and the sinuosity of the paths. The flora there present consists in beeches and some centennial *Camellia japonica*.
- Arboretum – As the name implies, it is a collection of trees, of various species, especially exotic. Many are very old and large as the lime trees and cedars. Some are unique specimens in the park as the camphor tree. There is also a magnificent sized cork oak and a giant sequoia.

The Museum Gardens differ from the other areas because of the age and origin of the species and the type of maintenance. The maintenance controls the spontaneous character of the communities that are present there. The majority of the species there existing are native to the region. It is divided in different areas, which are [35, 36, 38]:

- Holm-oak Clearing – a space with great ecological richness. It consists in a meadow punctuated by a shrubby mass, framed by groves of birch and dense hedges with native character.
- Birch Glade – Located on the north side of the Museum this area it is a deciduous edge of birch trees that opens to a great lawn.
- Yew Glade - this area is constituted by columnar yew-trees with a shrubby mass.
- Elm Patio – where it is located the staircase that connects the Museum Gardens with the Woods. The monumental cedars are located in this region.

Transition Zone

- Woods – a place with a more closed, cold and natural character, where the native species are dominant in this area. The low maintenance required leads to an ecological succession that favours the local native species. It is considered a transition zone between the sequence of gardens (upper zone) and the agricultural zone (lower zone) [35, 36, 38]

- Lake Grove – it is a primitive zone of the park and it was included in Gréber designs in 1932. Its elevated number of exotic species make this zone similar to the Arboretum, but it is more closed and natural character makes it similar with the Woods. It contains a lake, with a waterfall created by Gréber, when he included this area in his plans, and an island in the centre of the lake [35, 36, 38].

Lower Zone

- Fields – they reflect the transformations of natural landscapes in agricultural landscapes. The biodiversity of animals and plants of this place is very high. Although there exist some human maintenance to make the Fields grow as they should, the habitats there present (cropland, meadows and slough) are almost natural, since the maintenance is trying to recreate the natural state of the area that we encounter along the country. This place is also important for the water cycles of the park because the water current that exists here regulates the cycles of water and nutrients of this soil, so that the area can be used for agricultural purposes [35, 36, 38].
- Agricultural Seat – pretends to show how the rural world is, by creating an image of rusticity. Still maintains a small building, which existed before 1932, where are located some farm materials for the farm animals (stable, cowshed…). The Serralves Park direction services, the workers offices and an investigation area are located in this area. It is also in here that some activities are developed: educational, environmental and cultural [35, 36, 38].
- Herb Garden – before 1995 it was located on the Museum area, but because of its construction, it moved west of Fields. It is composed by shrubs and herbaceous plants with aromatic, medical or cooking properties and in the centre of the garden there is a greenhouse [35, 36, 38].

Appendix III – Questionnaire sent to the four selected programs (Project Budburst, Nature’s Calendar, Nature’s Notebook and PEP725)

Questions:

Observation Method:

11. Should the use of a digital camera be mandatory?
    _____
(Why?_____)

Species Selection:

12. When you choose a plant species to monitor, what criteria do you use?

- Morphological features (Y / N)
- Conservation status (Y / N)
- Frequency representation of the plant on the study area (Y / N)
- Other:_____

(Why?_____)

Number of individuals to monitor for each species:

13. What’s the ideal number to use: _____
(Why?_____)
14. Have you established different numbers of individuals depending on the species to monitor? (Y / N)
    Which?:_____
(Why?_____)
15. What’s the minimum number of individuals that each volunteer should register of each species:_____
(Why?_____)

Observation Frequency:

16. How many times in a year should a volunteer go to the study area to monitor a species?
    _____
(Why?_____)

Data:

➢ **Quality Control**

17. How is the control of the volunteers’ data?
    _____
(Why?_____)
18. Are training sessions essential? If so, how many should be done in a year?
    _____
(Why?_____)

➢ **Process and Publication**

19. When calculating the mean of registers for each species, do we use all results, even if the monitored number for species by each volunteer is different, or not?
    _____
(Why?_____)
20. When to start treating data on the phenological tendencies? (ex: 2 years or more?)
    _____
(Why?_____)

Appendix IV – Email exchange with the selected programs for the survey

(Email sent to all 4 programs)

Dear Sir/Madam

I am a master student performing a study on plant phenology monitoring designs and there are some questions that I encountered in my research.

To be able to sustain, in a more scientific way, the choices in the monitoring methodology for a case study in Portugal involving citizen science, I would like to know some information on some particular methodological questions.

For that reason, I am asking if you could kindly answer to the survey that I’m sending in attach to this email, if you don’t mind to explain a bit more of the work you developed in the project you are developing. The questions are simple, and I am hoping that your concise answers will contribute greatly to the analysis that I am conducting.

The credits and collaboration, should you sent any, will be cited in any publication that I might develop in the course of my work.

Thank you in advance for your time.

Best regards

Yours sincerely.

(Answers)

Burdburst program:

Hi Ercila,

I'm sorry, but we will not be able to fill out your survey at this time.

Best of luck with your research,

Sara

Nature’s notebook program:

Hi Ercilia,

I've attached the answers to your questions to this email. Good luck with your project!

Appendix V – Email exchange with the programs found to establish partnerships

(Email sent to Nature’s notebook, Nature’s calendar and Observatoire the Saesons)

Greetings

I’m a major student from Oporto Science University (FCUP,) in Portugal, and I’m doing a project that resembles your work, the study of phenology of plants. My study site will be a park that is associated to a Museum of Contemporary Art here in the city.

I would like to know if there is the possibility of creating a future scientific partnership between us and your foundation. I believe that it would be a major contribution for both parts.
In case you accept the offer, we may formalize the collaboration between institutions with protocols, if you see fit.

I’ll be waiting for you answer.

Thank you.

(Email sent to IPG)

Dear Sir:

I hope you are well.

I discovered your IPG site through the PEP725 project. As I studied it, I discovered that there are two IPG station on Portugal, which is my country. I’m an investigator of plant phenology study and, although my study doesn’t have the same conditions as your project (for example, the plants in study are not clones), I would like to know if you could give me some information about the IPG stations that exist in Porto and Évora and who should I make contact in there.

I would also like to ask if you could give me any contact from some members and associates from the PEP725 project that would be ideal to create a partnership with, because I tried to contact them, but I didn’t get any answer.

Thank you for your time.

Have a good day.

(Email sent to the PEP725)

Dear Sir/Madam:

I came across your site, which was referred by USA-NPN on an e-mail exchange, and it was an interesting discovery. I’m an investigator of plant phenology study and I’m very interested in your project being developed through Europe. I’m living in Portugal and I noticed that on your map, my country’s colour is white (so I guess no partnership has been established yet). With that said, I would like to know if it is possible for Portugal to be integrated in your research project and which conditions for being a

partner would be needed to allow the country’s phenology data to be integrated in your list through Europe.

Thank you for your time.

Have a good day.

(Answers)

PEP725 project:

Dear Ercilia

We are glad that you will join the PEP725 community.

A description about data format and data transfer is here http://www.pep725.eu/project/submitting.php

The database is open for any plants /phenological development stages as far as you provide the scientific name, and use the BBCH coding system BBCH codehttp://www.jki.bund.de/fileadmin/dam_uploads/_veroeff/bbch/BBCH-Skala_englisch.pdf

General guidelines http://www.omm.urv.cat/documentation.html Guidelines for plant phenological observations

Metadata are very important:

Coordinates of the observation (lat,lon) and a unique station id or name is required useful is also the altitude of the station (it gives us the possibility to cross check the coordinates, at least in the Alps)

Literature

General guidelines http://www.omm.urv.cat/documentation.html Guidelines for plant phenological observations

http://www4.uwm.edu/letsci/conferences/phenology2012/abstract_book.pdf

PEP725 Pan European Phenological Database, EGU 2012, Vienna, http://www.pep725.eu/downloads/EGU_2012.pdf

Trend of earlier spring in central Europe continued, EGU 2013, Vienna http://meetingorganizer.copernicus.org/EGU2013/EGU2013-4063.pdf

Last but not least I'd like to notice the difference between the USNPN observation and the historic way: The classic way is to observe and record single phenological events, e.g. 50% flowering of xxxx.

USNPN use a different approach, they tell the people every time you go outside report what you see AND what you don't see. So for 50% flowering of xxx the time series would look like N,N,N,Y,Y,Y,Y,N,N,N,...

To have this kind of data be stored in PEP725 you have to extract the date when the phenological event (e.g. BBCH 61 or BBCH 65) starts

Best regards

Elisabeth

Nature’s Notebook program:

Hi Ercilia,

We at the USA-NPN are always happy to hear about others conducting phenology monitoring around the globe and we are very happy to share our protocols, components of our IT infrastructure, and just experiences in general! Are you aware of the Pan European Phenology Project (PEP725)? That would also be a good group for you to be in touch with. Their website is www.pep725.eu and they have a Facebook group set up to stay in contact.

If you are particularly interested in protocols, we just published the standardized protocols we have developed over the last 6 years and you can access them here:

http://link.springer.com/article/10.1007/s00484-014-0789-5

There is a supplemental file that includes the details of our phenophase definitions, and although developed with US species in mind, they are general enough to be applied anywhere. We’d love to see them used more universally to facilitate comparisons of phenology across the globe.

Ellen

Appendix VI – Species selection table

Flora species of Serralves Park	Life Form			Biogeographic Distribution				Origin		Invasive Nature		Present structures and visibility					Conservation Status
	Tree	Shrub	Herbaceous	Temperate	Mediterranean	Continental	Sub-Tropical	Native	Exotic	Yes	No	Leafs	Scales	Needles	Flowers	Fruits	
Abelia x-grandiflora (André) Rehder		X		X	X		X		X		X	X			X		
Abies alba Mill.	X			X		X		X			X			X		X	LC
Acacia dealbata Link.	X	X		X	X				X	X		X			X	X(!)	
Acacia retinodes Schltdl.	X	X		X					X		X	X			X	X(!)	
Acer campestre L.	X					X			X		X	X			X(!)	X(!)	
Acer negundo L.	X	X		X					X		X	X			X(!)	X(!)	
Acer palmatum Thunb.	X			X					X		X	X			X(!)	X	
Acer palmatum Thunb. cult. Atropurpureum	X			X					X		X	X			X(!)	X	
Acer platanoides L.	X			X					X		X	X			X(!)	X	
Acer platanoides L. cult. Atropurpureum	X			X					X		X	X			X(!)	X	
Acer pseudoplatanus L.	X	X		X				X				X			X(!)	X	
Acer saccharinum L.	X			X					X		X	X			X(!)	X	
Aesculus hippocastanum L.	X			X					X		X	X			X	X	NT
Aesculus x-carnea Hayne	X			hybrid					X		X	X			X	X	NE
Ageratina ligustrina (DC.) R.M.King & H.Rob.		X		X			X		X		X	X			X(!)	X(!)	
Albizia julibrissin Durazz.	X								X		X	X			X	X	NE
Alnus glutinosa (L.) Gaertn.	X	X		X	X			X			X	X			X(!)	X(!)	
Amelanchier ovalis Medik.	X	X		X		X		X			X	X			X	X	EN
Araucaria angustifolia (Bertoloni) Kuntze	X								X		X	X				X	
Araucaria heterophylla (Salisb.) Franco	X								X		X			X		X	
Arbutus unedo L.	X	X		X	X			X			X	X			X	X	LC
Aucuba japonica Thunb.		X							X		X	X			X(!)	X	
Aucuba japonica Thunb. cult. Serratifolia		X							X		X	X			X(!)	X	
Baeckea virgata (Forster & Forster) Andrews.																	
Banksia integrifolia L.	X			X					X		X	X			X	X	NE
Beaucarnea recurvata Lam.	X								X		X	X			X	X(!)	
Berberis japonica (Thunberg) de Candolle		X		X			X		X		X	X			X	X	
Betula alba L.	X	X		X				X			X	X			X	X(!)	
Betula papyrifera Marshall	X	X				X			X		X	X			X	X(!)	
Betula pendula Roth	X	X		X				X			X	X			X	X(!)	
Bougainvillea glabra Choisy		X					X		X		X	X			X	X	NE
Brachychiton populneus (Schott & Endlicher) Brown	X						X		X		X	X			X	X	NE
Buddleja davidii Franchet		X		X				X			X	X			X		
Buxus sempervirens L.		X		X				X			X	X			X(!)	X(!)	
Camellia japonica L.	X	X		X	X		X		X		X	X			X	X	NE
Castanea sativa Mill.	X			X					X		X	X			X(!)	X	
Casuarina equisetifolia J.R. & G. Forster	X					X	X		X		X			X	X(!)	X	
Catalpa bignonioides Walter	X					X			X		X	X			X	X	NE
Cedrus atlantica (Endl.) Carrière	X					X			X		X			X		X	
Cedrus atlantica (Endl.) Carrière	X								X		X			X		X	

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cult. Glauca																	
Cedrus deodara (Roxb. ex D.Don) Don	X					X			X		X			X		X	
Cedrus libani Barrel.	X				X				X		X			X		X	
Celtis australis L.	X			X	X			X			X	X			X(!)	X	
Cephalotaxus harringtonia (Forbes) Koch		X							X		X	X			X	X	LC
Ceratonia siliqua L.	X	X			X				X		X	X			X(!)	X	
Cercis siliquastrum L.	X				X				X		X	X			X	X	NE
Cestrum parqui L.Herit.		X			X				X		X	X			X	X	NE
Chamaecyparis lawsoniana (A.Murray) Parl.	X								X		X		X			X	
Chamaecyparis lawsoniana (A.Murray) Parl. cult. Aurea									X		X						
Chamaecyparis lawsoniana (A.Murray) Parl. cult. Elegantissima									X		X						
Chamaecyparis obtusa (Siebold & Zuccarini) Endlicher	X			X			X		X		X		X			X	
Chorisia speciosa A. St.-Hil.	X						X		X		X	X			X	X	NE
Cinnamomum camphora (L.) T.Nees & C.H.Eberm.	X			X		X			X		X	X			X	X	NE
Citrus deliciosa Tenor	X				X				X		X	X			X	X	NE
Citrus limon (L.) Burm. fil.	X					X			X		X	X			X	X	NE
Citrus sinensis (L.) Osbeck	X						X		X		X	X			X	X	NE
Cleyera japonica Thunb. cult. Tricolor		X		X		X			X		X	X					
Cocculus laurifolius de Candolle	X	X				X			X		X	X			X(!)	X	
Cordyline australis (Forster) Endlicher	X	X		X					X		X	X			X	X(!)	
Cornus sanguinea L.		X		X		X		X			X	X			X	X	
Corylus avellana L.	X	X		X				X			X	X			X	X	LC
Cotoneaster tomentosus Lindl.		X		X	X				X		X	X			X	X	
Crataegus laevigata (Poiret) de Candolle cult. Roseoplena	X	X			X	X			X		X	X			X	X	LC
Crataegus monogyna Jacq.	X	X		X	X			X			X	X			X	X	LC
Cryptomeria japonica (L. f.) D.Don cult. Elegans	X			X					X		X			X		X(!)	
Cryptomeria japonica (L. f.) D.Don cult. Nana		X		X					X		X			X		X(!)	
Cupressus lusitanica Mill.	X				X				X		X		X		X(!)	X(!)	
Cupressus sempervirens L.	X				X				X		X		X		X(!)	X(!)	
Cycas revoluta Thunberg		X		X		X			X		X	X				X	
Cydonia oblonga L.	X				X				X		X	X			X	X	NE
Deutzia crenata Siebold & Zucc.		X		X		X	X		X		X	X			X	X	
Dicksonia antartica Labill.		X			X	X			X		X	X					
Diospyros kaki L.	X			X		X			X		X	X			X	X	NE
Dracaena draco (L.) L.	X			X		X		X			X	X			X(!)	X(!)	
Elaeagnus pungens Thunb.		X		X					X		X	X			X	X	NE
Erica arborea	X	X		X	X			X			X			X	X		
Eriobotrya japonica (Thunb.) Lindl	X			X		X			X		X	X			X	X	NE
Escallonia revoluta (Ruiz & Pavon) Persoon.		X					X		X		X	X			X		
Eucalyptus globulus Labill. subsp. globulus	X			X	X				X		X	X			X(!)	X	
Eucalyptus robusta Smith	X				X				X		X	X			x(!)	X	
Euonymus japonicus Thunb.	X	X		X		X			X		X	X			X(!)	X	NE

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Euonymus japonicus Thunb. cult. Variegata	X	X							X		X	X			X(!)	X	NE
Fagus sylvatica L.	X			X	X			X			X	X			X	X	NE
Fagus sylvatica L. cult. Asplenifolia	X			X	X			X			X	X			X	X	NE
Fagus sylvatica L. cult. Atropurpurea	X			X	X			X			X	X			X	X	NE
Fastia japonica (Thunb.) Decne. & Planch.		X		X					X		X	X			X(!)	X	
Ficus carica L.	X				X			X			X	X			X(!)	X	LC
Forsythia intermedia Zabel		X		hybrid										X	X		
Frangula alnus Mill.		X		X	X			X			X	X			X(!)	X	LC
Fraxinus angustifolia Vahl	X			X	X	X		X			X	X			X(!)	X	LC
Fraxinus ornus L.	X				X				X		X	X			X(!)	X	
Gardenia jasminoides J. Ellis		X		X		X			X		X	X			X	X	
Ginkgo biloba L.	X								X		X	X			X	X	EN
Grevillea robusta A.Cunn.	X						X		X		X	X			X(!)		
Hibiscus rosa-sinensis L.		X					X		X		X	X			X		
Ilex aquifolium L.	X	X		X				X			X	X			X	X	LC
Ilex aquifolium L. cult. Variegata				X				X			X	X			X	X	LC
Jacaranda mimosifolia D.Don	X				X		X		X		X	X			X	X	VU
Jasminum humile L.		X							X		X	X			X	X	NE
Juglans regia L.	X			X		X			X		X	X			X(!)	X	NT
Juniperus communis L.	X	X		X				X			X	X			X(!)	X	LC
Juniperus sabina L.		X			X	X			X		X		X		X	X	LC
Laburnum anagyroides Medicus	X	X			X	X			X		X	X			X	X	NE
Lagerstroemia indica L.	X	X		X	X	X	X		X		X	X			X	X	NE
Lantana camara L.		X					X		X		X	X			X(!)	X(!)	
Laurus nobilis L.	X	X		X	X			X			X	X			X	X	LC
Leptospermum laevigatum (Gaertner) F. Muell.	X	X		X			X		X		X	X			X	X	NE
Ligustrum japonicum Thunb.		X		X		X			X		X	X			X(!)	X(!)	
Ligustrum lucidum Aiton	X	X				X			X		X	X			X(!)	X(!)	
Ligustrum ovalifolium Hassk cult. Aureo-marginatum									X		X						
Ligustrum ovalifolium Hassk.		X		X		X			X		X	X			X(!)	X(!)	
Ligustrum sinense Lour.		X				X	X		X		X	X			X(!)	X(!)	
Ligustrum vulgare L.		X		X	X			X			X	X			X(!)	X	
Liquidambar styraciflua L.	X			X			X		X		X	X			X	X	LC
Liriodendron tulipifera L.	X			X					X		X	X			X	X	NE
Lycianthes rantonnetii (Carrière) Bitter		X					X		X		X	X			X	X	NE
Magnolia denudata Desr.	X					X			X		X	X			X	X	LC
Magnolia grandiflora L.	X			X		X			X		X	X			X	X	LC
Magnolia stellata (Siebold & Zuccarini) Maximowicz	X			X		X			X		X	X			X	X	NE
Magnolia x-soulangeana Hort.	X	X		hybrid										X	X	X	NE
Malus domestica Borkh.	X					X			X		X	X			X	X	NE
Melia azedarach L.	X			X		X	X		X		X	X			X(!)	X	
Metrosideros robusta Cunningham	X						X		X		X	X			X(!)		
Michelia figo (Lour.) Spreng.	X	X				X			X		X	X			X		
Morus nigra L.	X					X			X		X	X			X(!)	X	
Myrtus communis L.		X		X	X			X			X	X			X	X	NE
Nerium oleander L.	X	X			X			X			X	X			X	X	LC
Olea europaea L. var. europaea	X	X			X				X		X	X			X(!)	X	

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Osmanthus heterophyllus (G.Don) P.S.Green	X	X		X		X			X		X	X			X(!)	X	NE
Paulownia tomentosa (Thunberg) Steudel	X					X			X		X	X			X	X	NE
Philadelphus coronarius L.		X			X			X			X	X			X	X	NE
Photinia serratifolia (Desf.) Kalkman		X		X		X			X		X	X			X(!)	X	
Picea abies (L.) Karsten	X					X			X		X			X		X	
Pinus pinaster Aiton.	X			X	X				X		X			X		X	
Pinus pinea L.	X				X			X			X			X		X	LC
Pinus radiata D.Don	X			X					X		X			X		X	
Pittosporum eugenioides A.Cunningham	X			X					X		X	X			X	X	NE
Pittosporum tenuifolium Gaertner	X			X					X		X	X			X	X	NE
Pittosporum tobira (Thunb.) W.T. Aiton		X		X		X			X		X	X			X	X	NE
Pittosporum undulatum Ventenat.	X			X					X	X		X			X	X	NE
Platanus x-hispanica Mill. ex Münchh.	X			hybrid								X			X(!)	X	
Platycladus orientalis L.	X			X		X			X		X		X			X	
Populus nigra L.	X			X	X	X			X		X	X			X(!)	X(!)	LC
Populus x canadensis Moench	X			hybrid										X	X(!)	X(!)	
Prunus armeniaca L.	X					X			X		X	X			X	X	LC
Prunus avium L.	X			X	X			X			X	X			X	X	LC
Prunus cerasifera Ehrh.	X	X		X		X			X		X	X			X	X	NE
Prunus domestica L.	X	X		hybrid										X	X	X	NE
Prunus laurocerasus L.	X	X		X					X		X	X			X	X	LC
Prunus lusitanica L.	X			X		X		X			X	X			X	X	VU
Prunus persica (L.) Batsch	X					X			X		X	X			X	X	NE
Prunus spinosa L.	X			X	X			X			X	X			X	X	LC
Pseudotsuga menziesii (Mirb.) Franco	X			X		X			X		X			X		X	
Punica granatum L.	X				X	X			X		X	X			X	X	LC
Pyracantha angustifolia (Franchet) Schneider		X				X			X		X	X			X	X	NE
Pyrus communis L.	X			X					X		X	X			X	X	LC
Pyrus communis subsp. Piraster	X	X		X					X		X	X			X	X	NE
Quercus coccinea Muench.	X	X	X		X			X			X	X			X(!)	X	
Quercus faginea Lam.	X			X	X			X			X	X			X(!)	X	NE
Quercus ilex L.	X	X			X			X			X	X			X(!)	X	NT
Quercus palustris Muenchh	X	X		X		X			X		X	X			X(!)	X	
Quercus pyrenaica Willd.	X	X		X				X			X	X			X(!)	X	
Quercus robur L.	X	X		X				X			X	X			X(!)	X	LC
Quercus rubra L.	X	X		X		X			X		X	X			X(!)	X	
Quercus suber L.	X	X		X	X			X			X	X			X(!)	X	
Rhamnus alaternus L.		X			X			X			X	X			X(!)	X	NE
Rhaphiolepis umbellata (Thunb.) Makino		X		X		X			X		X	X			X	X	NE
Rhododendron arboreum Sm.	X	X		X		X			X		X	X			X	X	NE
Rhododendron sp.	X	X		X					X		X	X			X	X	NE
Rhododendron ponticum L.		X		X	X			X			X	X			X	X	NE
Robinia pseudoacacia L.	X			X					X	X		X			X	X	LC
Salix atrocinerea Brot.	X	X		X	X			X			X	X			X(!)	X	
Salix babylonica L.	X	X		X		X			X		X	X			X(!)	X	
Salix viminalis L.		X		X	X				X		X	X			X(!)	X	

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Sambucus nigra L.	X	X		X				X			X	X			X(!)	X	
Sciadopitys verticillata (Thunberg) Siebold & Zuccarini	X	X		X					X		X			X		X	
Sequoia sempervirens (D.Don) End.	X			X		X			X		X			X		X	
Sequoiadendron giganteum (Lindley) Buchholz	X			X		X			X		X		X			X	
Solanum erianthum D. Don	X	X		X		X			X		X	X			X	X	NE
Sorbus aucuparia L.	X	X		X				X			X	X			X(!)	X	
Spiraea cantoniensis Lour.		X		X					X		X	X			X	X	NE
Taxus baccata L.	X			X	X			X			X	X			X(!)	X	VU
Taxus baccata L. cult. Fastigiata	X										X	X			X(!)	X	LC
Taxus baccata L. cult. Repens	X			X	X						X	X			X(!)	X	
Thuja occidentalis L.	X			X		X			X		X		X			X	
Thuja plicata D.Don	X			X		X					X		X			X	
Thujopsis dolabrata Siebold & Zuccarini	X			X					X		X		X			X	
Tibouchina urvilleana (de Candolle) Cogniaux.		X					X		X		X	X			X	X	NE
Tilia platyphyllos Scop. subsp. platyphyllos	X				X	X			X		X	X			X(!)	X	LC
Tilia tomentosa Moench	X					X			X		X	X			X(!)	X	
Ulmus glabra Hudson cult. Camperdownii	X					X			X		X	X				X	
Ulmus minor Miller	X			X		X		X			X	X				X	
Ulmus pumila L.	X			X		X			X		X	X			X(!)	X(!)	
Viburnum odorantissimum Ker.	X	X				X			X		X	X			X(!)	X	
Viburnum opulus L.	X	X		X	X			X			X	X			X(!)	X	
Viburnum sieboldii Miq.	X	X		X					X		X	X			X	X	NE
Viburnum rhytidophyllum Hemsley	X	X		X		X			X		X	X			X(!)	X	
Viburnum tinus L.		X			X			X			X	X			X	X	NE
Weigela florida (Bunge) de Candolle		X		X		X			X		X	X			X	X	NE
Wisteria floribunda (Willd.) DC.	X			X					X		X	X			X(!)	X	NE
Yucca filamentosa L.			X	X		X			X		X	X			X	X	NE

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Appendix VII – List of the 22 selected species, and number of exemplars for each one, for "Serralves em Flora" project

Árvore	Nativa	Folha	Flor	Fruto
Prunus lusitanica L. (3)				
Prunus spinosa L. (3)				

Árvore/Arbusto	Nativa	Folha	Flor	Fruto
Amelanchier ovalis Medik. (4)				
Arbutus unedo L. (3)				
Corylus avellana L. (5)				
Crataegus monogyna Jacq. (5)				
Ilex aquifolium L. (5)				

Arbusto	Nativa	Folha	Flor	Fruto
Viburnum tinus L. (5)				

Árvore	Exótica	Folha	Flor	Fruto
Citrus deliciosa Tenor (5)				
Citrus limon (L.) Burm. fil. (5)				
Citrus sinensis (L.) Osbeck (5)				
Cydonia oblonga L. (5)				
Ginkgo biloba L. (5)				
Prunus persica (L.) Batsch (5)				

Árvore/Arbusto	Exótica	Folha	Flor	Fruto
Prunus laurocerasus L. (4)				

Arbusto	Exótica	Folha	Flor	Fruto
Gardenia jasminoides J. Ellis (5)				
Rhaphiolepis umbellata (Thunb.) Makino (3)				
Tibouchina urvilleana (de Candolle) Cogniaux (4)				

Excepções
Buxus sempervirens L. (4)
Laurus nobilis L. (3)
Quercus robur L. (3)
Taxus baccata L. (3)

Appendix VIII – “Serralves em Flora” monitoring sheets of the 22 species

Fichas de monitorização

1. O que é o SERRALVES EM FLORA?

Serralves em Flora é um projeto de ciência feito pelo cidadão (*citizen science*), que visa a **monitorização das fenofases das árvores e arbustos do Parque de Serralves.**

Designam-se por **fenofases** as fases do ciclo de vida dos organismos, neste caso, eventos como o aparecimento e queda das folhas em espécies caducifólias; a floração e a frutificação.

A **monitorização fenológica** das árvores e arbustos consiste na observação e registo periódicos dessas fenofases, em exemplares pré-definidos.

Este projeto tem como objetivo relacionar os dados recolhidos com as condições climáticas presentes e futuras, de forma a identificar possíveis alterações ao longo do tempo e percecionar a sua influência.

Serralves em Flora está a ser desenvolvido em colaboração com a aluna da Faculdade de Ciências da Universidade do Porto, Ercília Monteiro, no âmbito da sua tese para obtenção do grau de mestre em Ecologia, Ambiente e Território, orientada pelas investigadoras Cristiana Vieira e Sofia Viegas (CIBIO-InBIO).

2. Protocolo de amostragem

Como monitorizar

Antes de iniciares

1. Para participares neste projeto, deverás deslocar-te preferencialmente a todos os grupos de árvores ou arbustos identificados no mapa, representativos de cada uma das espécies.
2. Deves observar cuidadosamente a planta (exemplar numerado e identificado no local) antes de iniciares o preenchimento da tabela.
3. O preenchimento da tabela deve ser feito para cada uma das plantas.
4. Para fazeres esta **monitorização não é necessário recolher qualquer tipo de material (folhas, flores ou frutos)**. A recolha de folhas, flores ou frutos pode prejudicar o crescimento e desenvolvimento da planta e influenciar a monitorização das fenofases seguintes.
5. Cada uma das fenofases está ilustrada por uma fotografia, de forma a facilitar a sua identificação.

Iniciar a monitorização

1. Regista a **data da observação** (dia/mês/ano).
2. Dirige-te ao exemplar 1 de cada grupo.
3. Observa cuidadosamente toda a planta.
4. Regista a **presença** (escrevendo “**S**” de sim) ou **ausência** (escrevendo “**N**” de não) das **fenofases** listadas na tabela.
5. Repete os passos anteriores para as restantes plantas da mesma espécie.

Finalizar a inventariação

Visita a plataforma de monitorização do Parque de Serralves: Biodiversidade e Ambiente, e regista as tuas observações no módulo Serralves em Flora.

Diverte-te e obrigado!

Nome

Científico: *Amelanchier ovalis* Medik.

Comum: ----------

Local: Parque de Serralves

Número de identificação

Exemplar 1	Exemplar 2	Exemplar 3	Exemplar 4
14971	14969	14967	14965

Localização dos exemplares no Parque: Clareira dos Teixos

Registo:

Data:	

Fases	É visível…	Exemplares 1	2	3	4
FO (Folhas)	**[1] … o desenrolar das 1ªs folhas?** (As primeiras folhas estão totalmente desenroladas?)				
	[2] … o desenrolar das folhas? (Metade das folhas da planta estão já totalmente desenroladas?)				
FL (Flores)	**[1] … o início da floração?** (A planta está coberta de botões de flores e as primeiras flores estão abertas?)				
	[2] … a floração intermédia? (Metade da planta, ou mais, está coberta de flores abertas e algumas das pétalas já começam a cair?)				
	[3] … a floração final? (A maior parte das flores está sem pétalas ou com pétalas secas?)				
FR (Frutos)	**[1] … o início da frutificação?** (Estão visíveis os primeiros frutos?)				
	[2] … o início da maturação dos frutos? (Os primeiros frutos imaturos estão a ficar avermelhados?)				
	[3] … a maturação dos 1os frutos? (A planta está coberta de frutos imaturos e os primeiros frutos exibem a cor negro-azulada – maduros?)				
	[4] … a maturação completa dos frutos? (Mais de metade dos frutos estão maduros e já começam a cair?)				
SE (Senescência)	**[1] … o início da coloração de Outono?** (Algumas das folhas estão a perder a sua cor verde original?)				
	[2] … a coloração de Outono? (Metade das folhas, ou mais, perderam a cor original?)				
	[3] … a queda outonal das folhas? (A planta já perdeu metade das folhas, ou mais?)				
	[4] … o fim da queda outonal das folhas? (A planta já quase não tem folhas?)				

Fotos das diferentes fases:

Desenrolar das 1as folhas

Desenrolar das folhas

Início da floração

Floração intermédia

Floração final

Início da frutificação

Início de maturação dos frutos

Maturação dos 1os frutos

Maturação completa dos frutos

Início de Coloração de Outono

Coloração de Outono

Queda outonal

Fim da queda outonal

Nome

Científico: *Arbutus unedo* L.

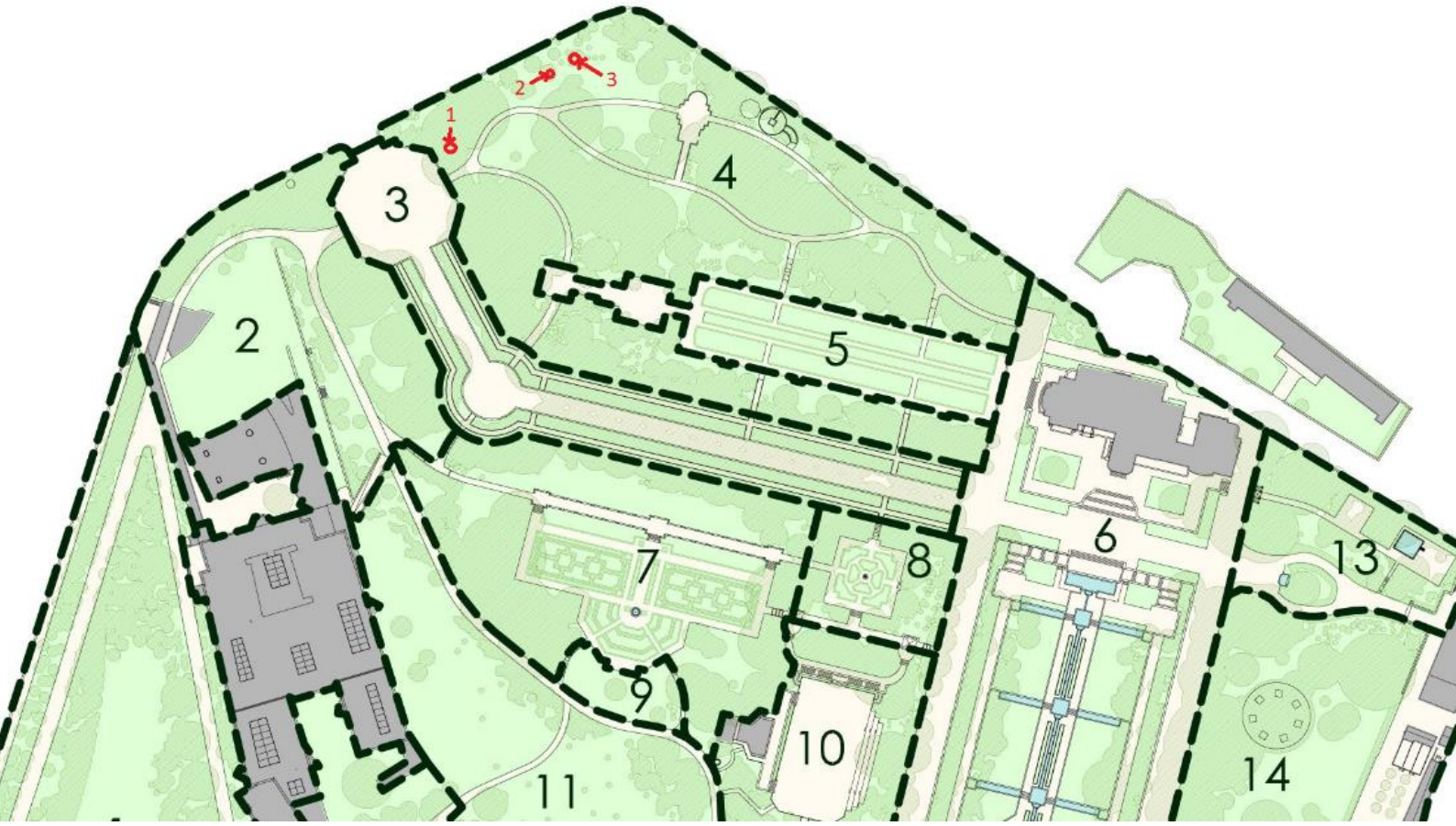
Comum: Medronheiro

Local: Parque de Serralves

Número de identificação

Exemplar 1	Exemplar 2	Exemplar 3
11904	11971	11980

Localização dos exemplares no Parque: Bosque das Faias



Registo:

Data:	

Fases	É visível...	Exemplares 1	2	3
FL (Flores)	**[1] … o início da floração?** (A planta está coberta de botões de flores e as primeiras flores estão abertas?)			
	[2] … a floração intermédia? (Metade da planta, ou mais, está coberta de flores abertas e algumas já começam a cair?)			
	[3] … a floração final? (A maior parte da planta está sem flores?)			
FR (Frutos)	**[1] … o início da frutificação?** (Estão visíveis os primeiros frutos (medronhos)?)			
	[2] … o início da maturação dos frutos? (Os primeiros medronhos imaturos estão a ficar avermelhados?)			
	[3] … a maturação dos 1os frutos? (A planta está coberta de medronhos imaturos e os primeiros medronhos exibem a cor vermelha – maduros?)			
	[4] … a maturação completa dos frutos? (Mais de metade dos medronhos estão maduros e já começam a cair?)			

Fotos das diferentes fases

Início da floração

Floração intermédia

Floração final

Início da frutificação

Início de maturação dos frutos

Maturação dos 1os frutos

Maturação completa dos frutos

Nome

Científico: *Buxus sempervirens* L.

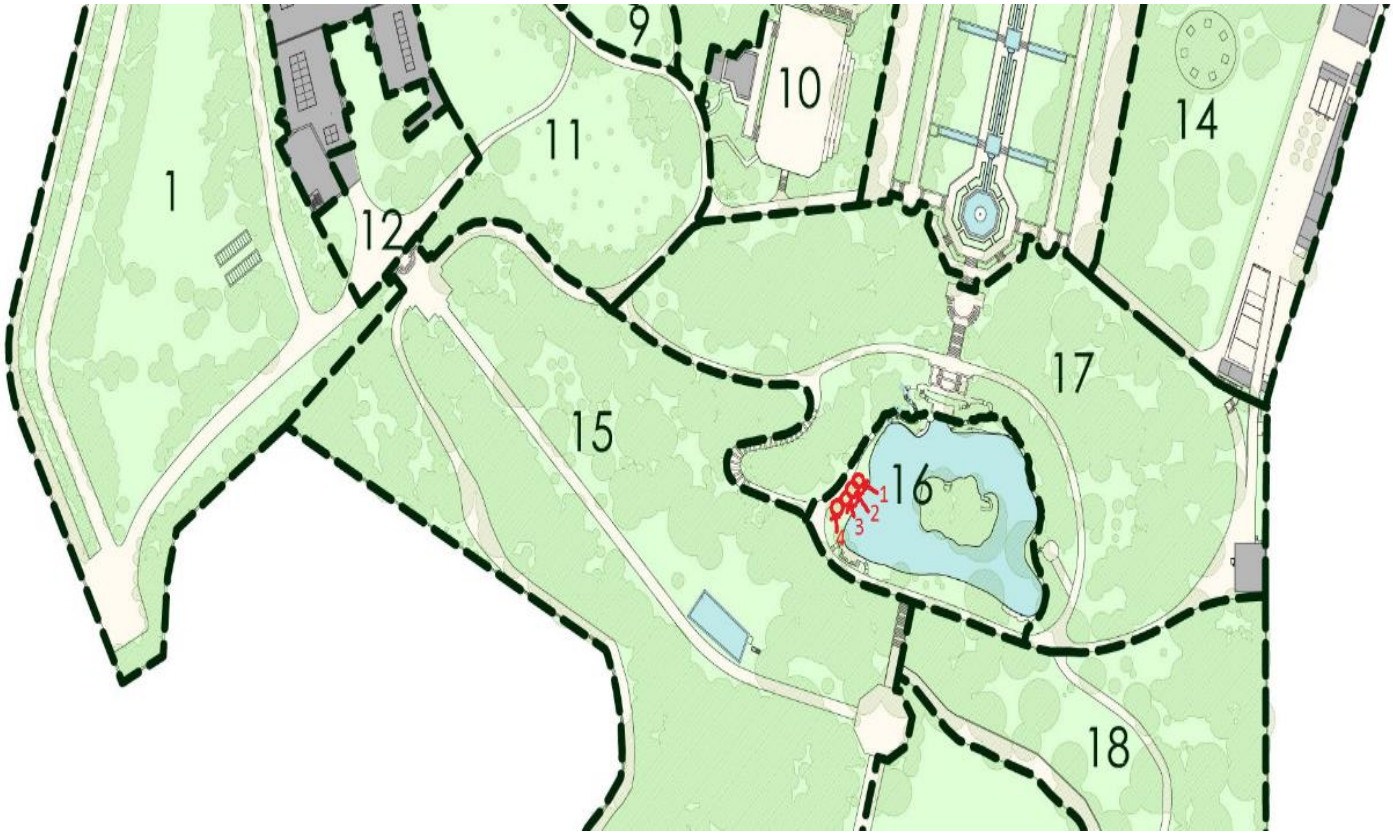
Comum: Buxo

Local: Parque de Serralves

Número de identificação

Exemplar 1	Exemplar 2	Exemplar 3	Exemplar 4
14006	14007	14010	14011

Localização dos exemplares no Parque: Lago



Registo:

Data:	

		Exemplares			
Fases	**É visível…**	**1**	**2**	**3**	**4**
FL (Flores)	**[1] … o início da floração?** (A planta está coberta de botões de flores e as primeiras flores estão abertas?)				
	[2] … a floração intermédia? (Metade da planta, ou mais, está coberta de flores abertas e algumas já começam a cair?)				
	[3] … a floração final? (A maior parte da planta está sem flores?)				
FR (Frutos)	**[1] … o início da frutificação?** (Estão visíveis os primeiros frutos?)				
	[2] … o início da maturação dos frutos? (Os primeiros frutos imaturos estão a ficar acastanhados?)				
	[3] … a maturação dos 1os frutos? (A planta está coberta de frutos imaturos e os primeiros frutos exibem a cor castanha – maduros?)				
	[4] … a maturação completa dos frutos? (Mais de metade dos frutos estão maduros e já começam a abrir?)				

Fotos das diferentes fases:

Início da floração

Floração intermédia

Floração final

Início da frutificação

Início de maturação dos frutos

Maturação dos 1os frutos

Maturação completa dos frutos

Nome

Científico: *Citrus deliciosa* Tenor

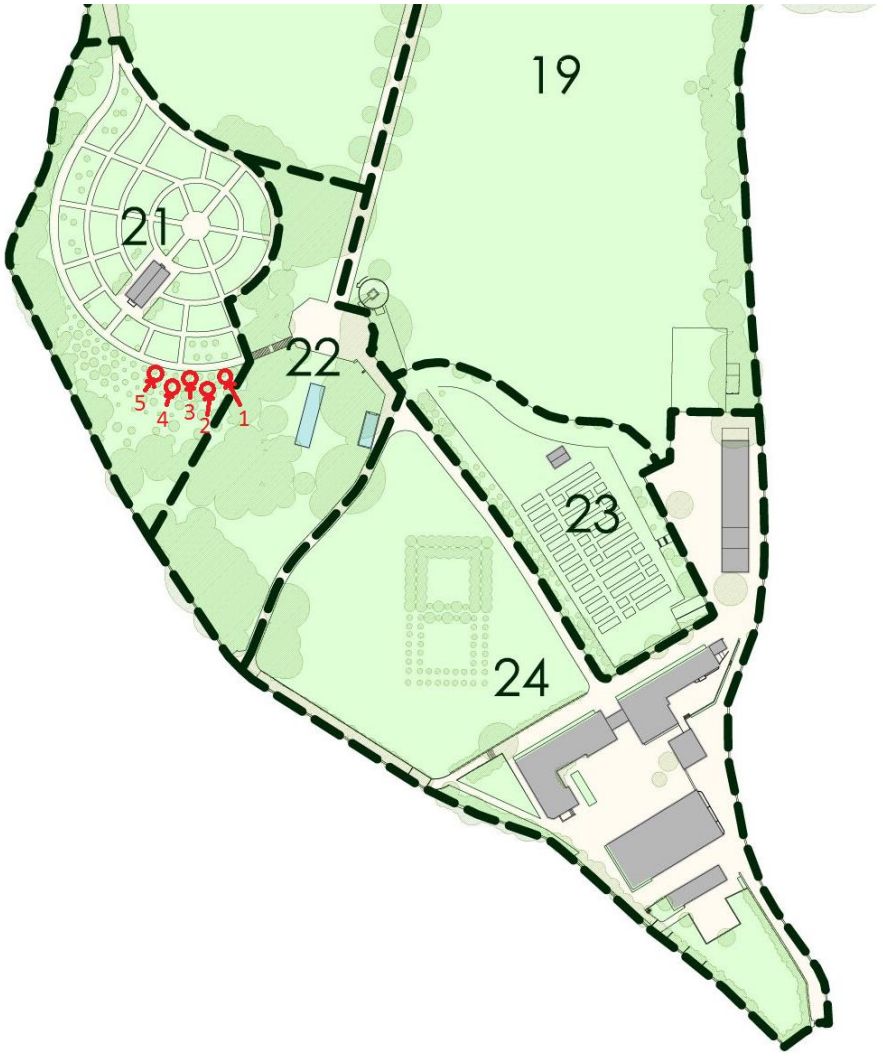
Comum: Tangerineira “Montenegrina”

Local: Parque de Serralves

Número de identificação

Exemplar 1	Exemplar 2	Exemplar 3	Exemplar 4	Exemplar 5
1969	2217	1963	2173	1957

Localização dos exemplares no Parque: Jardim das Aromáticas



Registo:

Data:	

Fases	É visível…	Exemplares 1	2	3	4	5
FL (Flores)	**[1] … o início da floração?** (A planta está coberta de botões de flores e as primeiras flores estão abertas?)					
	[2] … a floração intermédia? (Metade da planta, ou mais, está coberta de flores abertas e algumas das pétalas já começam a cair?)					
	[3] … a floração final? (A maior parte das flores está sem pétalas ou com pétalas secas?)					
FR (Frutos)	**[1] … o início da frutificação?** (Estão visíveis os primeiros frutos (tangerinas)?)					
	[2] … o início da maturação dos frutos? (As primeiras tangerinas imaturas estão a ficar alaranjadas?)					
	[3] … a maturação dos 1os frutos? (A planta está coberta de tangerinas imaturas e as primeiras tangerinas exibem a cor laranja-viva – maduras?)					
	[4] … a maturação completa dos frutos? (Mais de metade das tangerinas estão maduras e já começam a cair?)					

Fotos das diferentes fases:

Início da floração

Floração intermédia

Floração final

Início da frutificação

Início de maturação dos frutos

Maturação dos 1os frutos

Maturação completa

Nome

Científico: *Citrus limon* (L.) Burm. fil.

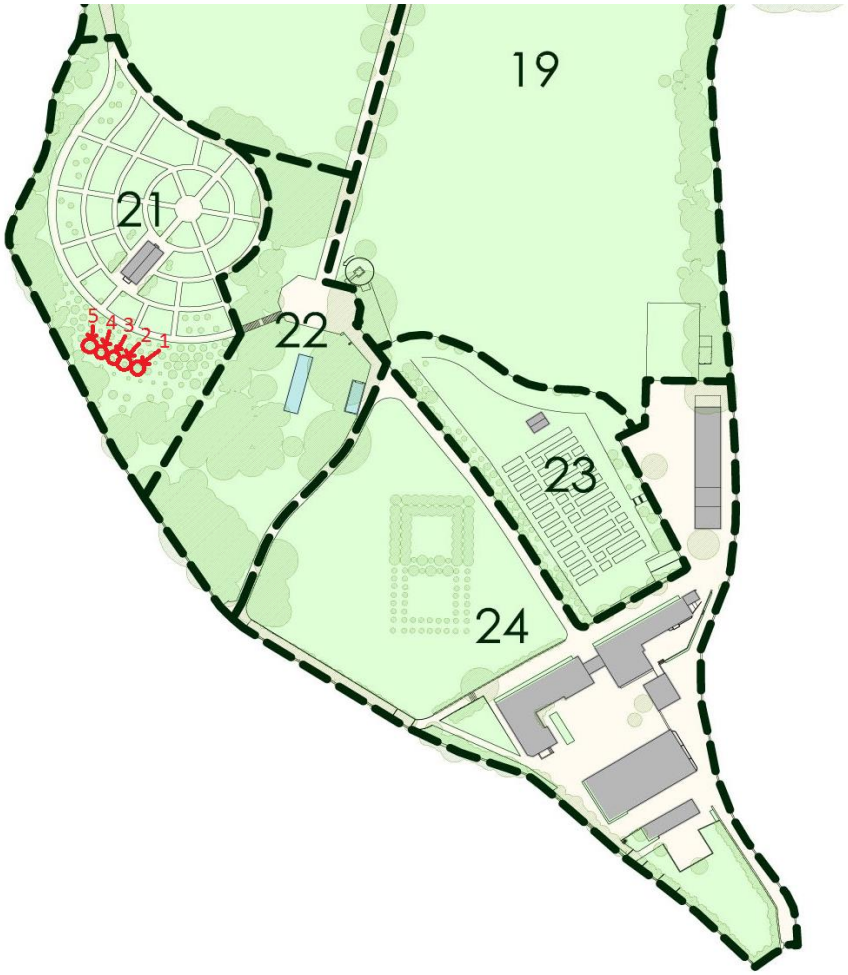
Comum: Limoeiro

Local: Parque de Serralves

Número de identificação

Exemplar 1	Exemplar 2	Exemplar 3	Exemplar 4	Exemplar 5
2215	1975	2197	2179	2185

Localização dos exemplares no Parque: Jardim das Aromáticas



Registo:

Data:	

Fases	É visível…	Exemplares 1	2	3	4	5
FL (Flores)	**[1] … o início da floração?** (A planta está coberta de botões de flores e as primeiras flores estão abertas?)					
	[2] … a floração intermédia? (Metade da planta, ou mais, está coberta de flores abertas e algumas das pétalas já começam a cair?)					
	[3] … a floração final? (A maior parte das flores está sem pétalas ou com pétalas secas?)					
FR (Frutos)	**[1] … o início da frutificação?** (Estão visíveis os primeiros frutos (limões)?)					
	[2] … o início da maturação dos frutos? (Os primeiros limões imaturos estão a ficar amarelados?)					
	[3] … a maturação dos 1os frutos? (A planta está coberta de limões imaturos e os primeiros limões exibem a cor amarela – maduros?)					
	[4] … a maturação completa dos frutos? (Mais de metade dos limões estão maduros e já começam a cair?)					

Fotos das diferentes fases:

Início da floração

Floração intermédia

Floração final

Início da frutificação

Início de maturação dos frutos

Maturação dos 1os frutos

Maturação completa dos frutos

Nome

Científico: *Citrus sinensis* (L.) Osbeck

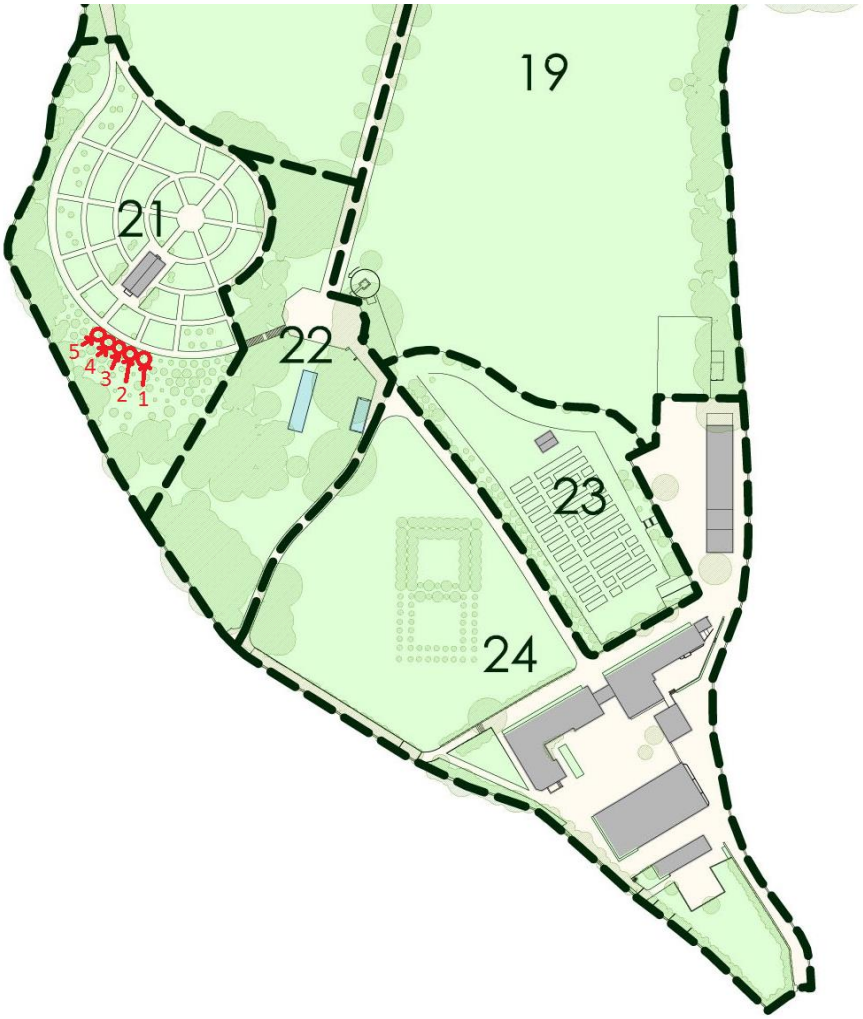
Comum: Laranjeira

Local: Parque de Serralves

Número de identificação

Exemplar 1	Exemplar 2	Exemplar 3	Exemplar 4	Exemplar 5
1945	2003	2001	1923	2059

Localização dos exemplares no Parque: Jardim das Aromáticas



Registo:

Data:	

		Exemplares				
Fases	**É visível…**	**1**	**2**	**3**	**4**	**5**
FL (Flores)	**[1] … o início da floração?** (A planta está coberta de botões de flores e as primeiras flores estão abertas?)					
	[2] … a floração intermédia? (Metade da planta, ou mais, está coberta de flores abertas e algumas das pétalas já começam a cair?)					
	[3] … a floração final? (A maior parte das flores está sem pétalas ou com pétalas secas?)					
FR (Frutos)	**[1] … o início da frutificação?** (Estão visíveis os primeiros frutos (laranjas)?)					
	[2] … o início da maturação dos frutos? (As primeiras laranjas imaturas estão a ficar alaranjadas?)					
	[3] … a maturação dos 1os frutos? (A planta está coberta de laranjas imaturas e as primeiras laranjas exibem a cor laranja – maduras?)					
	[4] … a maturação completa dos frutos? (Mais de metade das laranjas estão maduras e já começam a cair?)					

Fotos das diferentes fases:

Início da floração

Floração intermédia

Floração final

Início da frutificação

Início de maturação dos frutos

Maturação dos 1os frutos

Maturação completa dos frutos

Nome

Científico: *Corylus avellana* L.

Comum: Aveleira

Local: Parque de Serralves

Número de identificação

Exemplar 1	Exemplar 2	Exemplar 3	Exemplar 4	Exemplar 5
11140	11141	11146	11147	11118

Localização dos exemplares no Parque: Clareira das Azinheiras

Registo:

Data:	

Fases	É visível…	Exemplares 1	2	3	4	5
FO (Folhas)	**[1] … o desenrolar das 1ªs folhas?** (As primeiras folhas estão totalmente desenroladas?)					
	[2] … o desenrolar das folhas? (Metade das folhas da planta estão já totalmente desenroladas?)					
FR (Frutos)	**[1] … o início da frutificação?** (Estão visíveis os primeiros frutos (avelãs)?)					
	[2] … o início da maturação dos frutos? (As primeiras avelãs imaturas estão a ficar acastanhadas?)					
	[3] … a maturação dos 1os frutos? (A planta está coberta de avelãs imaturas e as primeiras avelãs exibem a cor castanha – maduras?)					
	[4] … a maturação completa dos frutos? (Mais de metade das avelãs estão maduras e já começam a cair?)					
SE (Senescência)	**[1] … o início da coloração de Outono?** (Algumas das folhas estão a perder a sua cor verde original?)					
	[2] … a coloração de Outono? (Metade das folhas, ou mais, perderam a cor original?)					
	[3] … a queda outonal das folhas? (A planta já perdeu metade das folhas, ou mais?)					
	[4] … o fim da queda outonal das folhas? (A planta já quase não tem folhas?)					

Fotos das diferentes fases:

Desenrolar das 1as folhas

Desenrolar das folhas

Início da frutificação

Início de maturação dos frutos

Maturação dos 1os frutos

Maturação completa dos frutos

Início de Coloração de Outono

Coloração de Outono

Queda outonal

Fim da queda outonal

Nome

Científico: *Crataegus monogyna* Jacq.

Comum: Pilriteiro

Local: Parque de Serralves

Número de identificação

Exemplar 1	Exemplar 2	Exemplar 3	Exemplar 4	Exemplar 5
15098	15099	15100	15101	15102

Localização dos exemplares no Parque: Clareira das Azinheiras

Registo:

Data:	

Fases	É visível…	Exemplares 1	2	3	4	5
FO (Folhas)	**[1] … o desenrolar das 1as folhas?** (As primeiras folhas estão totalmente desenroladas?)					
	[2] … o desenrolar das folhas? (Metade das folhas da planta estão já totalmente desenroladas?)					
FL (Flores)	**[1] … o início da floração?** (A planta está coberta de botões de flores e as primeiras flores estão abertas?)					
	[2] … a floração intermédia? (Metade da planta, ou mais, está coberta de flores abertas e algumas das pétalas já começam a cair?)					
	[3] … a floração final? (A maior parte das flores está sem pétalas ou com pétalas secas?)					
FR (Frutos)	**[1] … o início da frutificação?** (Estão visíveis os primeiros frutos?)					
	[2] … o início da maturação dos frutos? (Os primeiros frutos imaturos estão a avermelhados?)					
	[3] … a maturação dos 1os frutos? (A planta está coberta de frutos imaturos e os primeiros frutos exibem a cor vermelho-vivo – maduros?)					
	[4] … a maturação completa dos frutos? (Mais de metade dos frutos estão maduros e já começam a cair?)					
SE (Senescência)	**[1] … o início da coloração de Outono?** (Algumas das folhas estão a perder a sua cor verde original?)					
	[2] … a coloração de Outono? (Metade das folhas, ou mais, perderam a cor original?)					
	[3] … a queda outonal das folhas? (A planta já perdeu metade das folhas, ou mais?)					
	[4] … o fim da queda outonal das folhas? (A planta já quase não tem folhas?)					

Fotos das diferentes fases:


Desenrolar das 1as folhas


Desenrolar das folhas


Início da floração


Floração intermédia


Floração final


Início da frutificação


Início de maturação


1os frutos maduros


Maturação completa


Início de Coloração de Outono


Coloração de Outono


Queda outonal


Fim da queda outonal

Nome

Científico: *Cydonia oblonga* L.

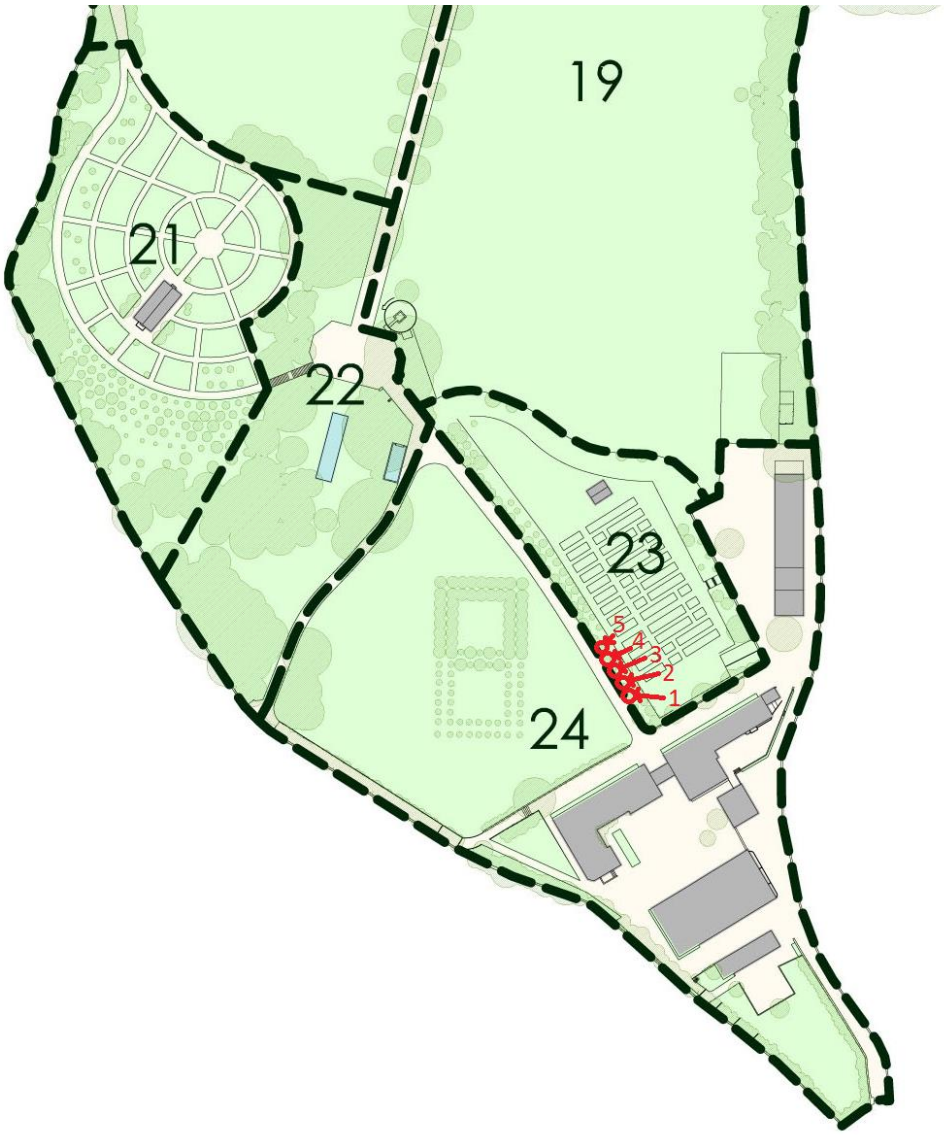
Comum: Marmeleiro

Local: Parque de Serralves

Número de identificação

Exemplar 1	Exemplar 2	Exemplar 3	Exemplar 4	Exemplar 5
2439	2437	2435	2433	2431

Localização dos exemplares no Parque: Horta Pedagógica



Registo:

Data:	

Fases	É visível…	Exemplares 1	2	3	4	5
FO (Folhas)	**[1] … o desenrolar das 1as folhas?** (As primeiras folhas estão totalmente desenroladas?)					
	[2] … o desenrolar das folhas? (Metade das folhas da planta estão já totalmente desenroladas?)					
FL (Flores)	**[1] … o início da floração?** (A planta está coberta de botões de flores e as primeiras flores estão abertas?)					
	[2] … a floração intermédia? (Metade da planta, ou mais, está coberta de flores abertas e algumas das pétalas já começam a cair?)					
	[3] … a floração final? (A maior parte das flores está sem pétalas ou com pétalas secas?)					
FR (Frutos)	**[1] … o início da frutificação?** (Estão visíveis os primeiros frutos (marmelos)?)					
	[2] … o início da maturação dos frutos? (Os primeiros marmelos imaturos estão a ficar amarelados?)					
	[3] … a maturação dos 1os frutos? (A planta está coberta de marmelos imaturos e os primeiros marmelos exibem a cor amarela – maduros?)					
	[4] … a maturação completa dos frutos? (Mais de metade dos marmelos estão maduros e já começam a cair?)					
SE (Senescência)	**[1] … o início da coloração de Outono?** (Algumas das folhas estão a perder a sua cor verde original?)					
	[2] … a coloração de Outono? (Metade das folhas, ou mais, perderam a cor original?)					
	[3] … a queda outonal das folhas? (A planta já perdeu metade das folhas, ou mais?)					
	[4] … o fim da queda outonal das folhas? (A planta já quase não tem folhas?)					

Fotos das diferentes fases:

Desenrolar das 1as folhas

Desenrolar das folhas

Início da floração

Floração intermédia

Floração final

Início da frutificação

Início de maturação

1os frutos maduros

Maturação completa

Início de Coloração de Outono

Coloração de Outono

Queda outonal

Fim da queda outonal

Nome

Científico: *Gardenia jasminoides* J. Ellis

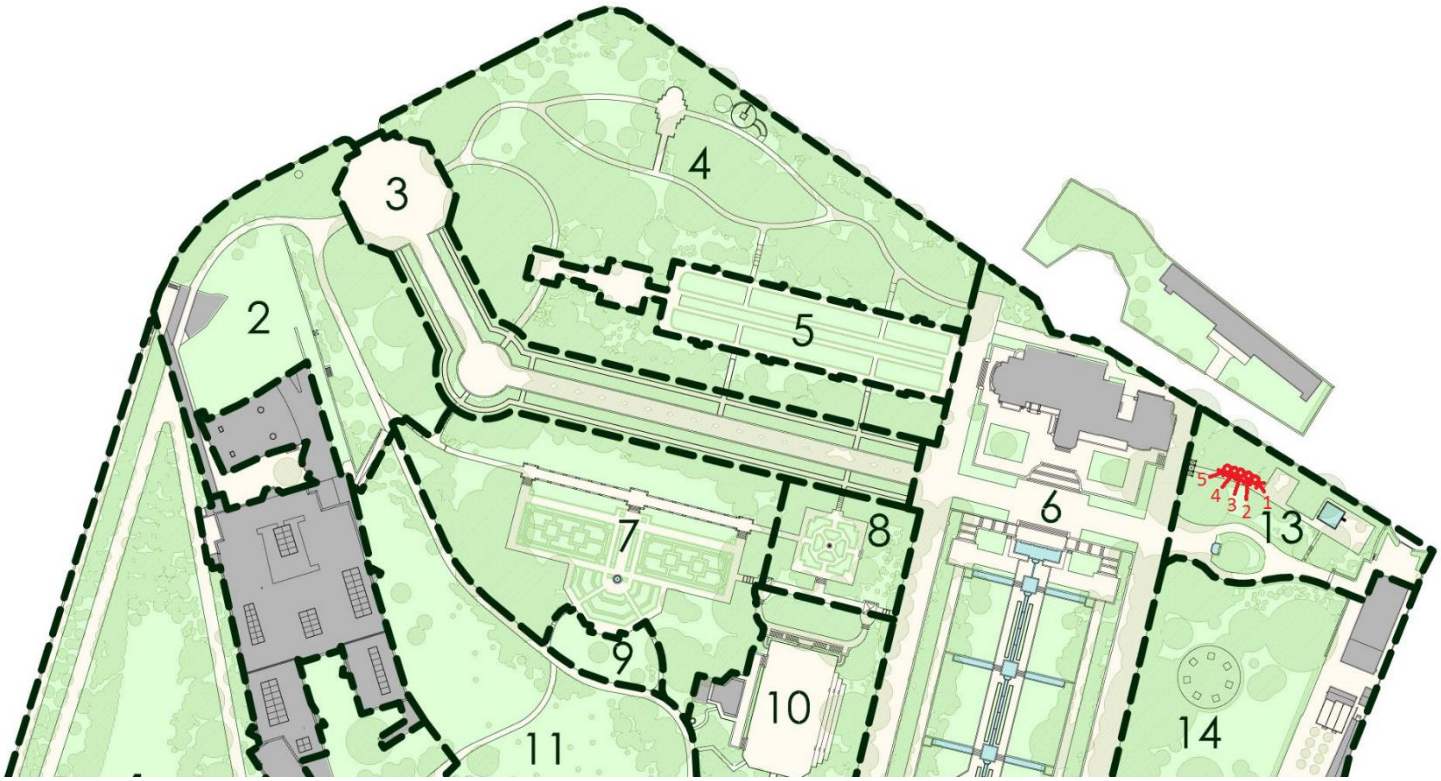
Comum: Gardenia

Local: Parque de Serralves

Número de identificação

Exemplar 1	Exemplar 2	Exemplar 3	Exemplar 4	Exemplar 5
14912	14913	14914	14915	14916

Localização dos exemplares no Parque: Jardim das Camélias



Registo:

Data:	

Fases	É visível…	Exemplares 1	2	3	4	5
FL (Flores)	**[1] …o início da floração?** (A planta está coberta de botões de flores e as primeiras flores estão abertas?)					
	[2] … a floração intermédia? (Metade da planta, ou mais, está coberta de flores abertas e algumas das pétalas já começam a cair?)					
	[3] … a floração final? (A maior parte das flores está sem pétalas ou com pétalas secas?)					
FR (Frutos)	**[1] … o início da frutificação?** (Estão visíveis os primeiros frutos?)					
	[2] … o início da maturação dos frutos? (Os primeiros frutos imaturos estão a ficar amareladas?)					
	[3] … a maturação dos 1os frutos? (A planta está coberta de frutos imaturos e os primeiros frutos exibem a cor laranja-viva – maduros?)					
	[4] … a maturação completa dos frutos? (Mais de metade dos frutos estão maduros e já começam a cair?)					

Fotos das diferentes fases:

Início da floração

Floração intermédia

Floração final

Início da frutificação

Início de maturação dos frutos

Maturação dos 1os frutos

Maturação completa dos frutos

Nome

Científico: *Ginkgo biloba* L.

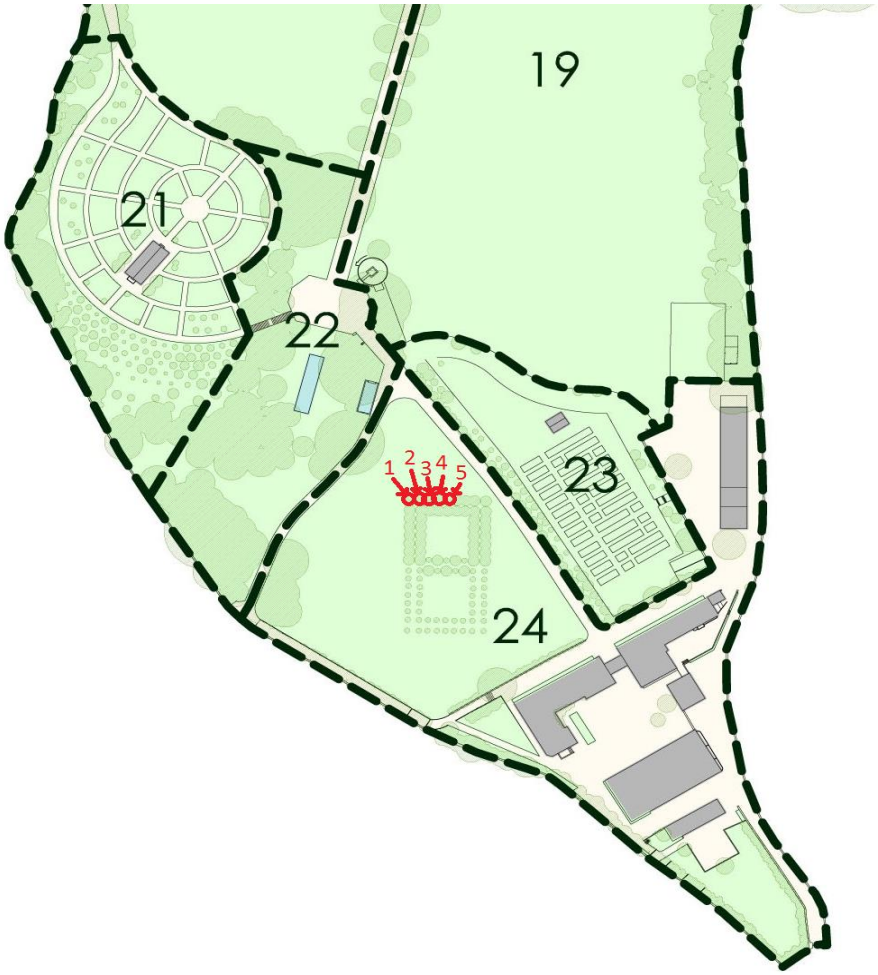
Comum: Ginkgo

Local: Parque de Serralves

Número de identificação

Exemplar 1	Exemplar 2	Exemplar 3	Exemplar 4	Exemplar 5
2595	2597	2599	2605	2607

Localização dos exemplares no Parque: Assento Agrícola do Mata-Sete



Registo:

Data:	

		Exemplares				
Fases	**É visível…**	**1**	**2**	**3**	**4**	**5**
FO (Folhas)	**[1] … o desenrolar das 1as folhas?** (As primeiras folhas estão totalmente desenroladas?)					
	[2] … o desenrolar das folhas? (Metade das folhas da planta estão já totalmente desenroladas?)					
FL (Flores)	**[1] … o início da floração?** (A planta está coberta de botões de flores e as primeiras flores estão abertas (macho/fêmea)?)					
	[3] … a floração final? (A maior parte da planta está sem flores ou com flores secas?)					
FR (Frutos)	**[1] … o início da frutificação?** (Estão visíveis os primeiros frutos?)					
	[2] … o início da maturação dos frutos? (Os primeiros frutos imaturos estão a ficar acastanhados?)					
	[3] … a maturação dos 1os frutos? (A planta está coberta de frutos imaturos e os primeiros frutos exibem a cor amarelo-acastanhada – maduros?)					
	[4] … a maturação completa dos frutos? (Mais de metade dos frutos estão maduros e já começam a cair?)					
SE (Senescência)	**[1] … o início da coloração de Outono?** (Algumas das folhas estão a perder a sua cor verde original?)					
	[2] … a coloração de Outono? (Metade das folhas, ou mais, perderam a cor original?)					
	[3] … a queda outonal das folhas? (A planta já perdeu metade das folhas, ou mais?)					
	[4] …o fim da queda outonal das folhas? (A planta já quase não tem folhas?)					

Fotos das diferentes fases:

Desenrolar das 1as folhas

Desenrolar das folhas

Início da floração (macho)

Início da floração (fêmea)

Floração final

Início da frutificação

Início de maturação dos frutos

Maturação dos 1os frutos

Maturação completa dos frutos

Início de Coloração de Outono

Coloração de Outono

Queda outonal

Fim da queda outonal

Nome

Científico: *Ilex aquifolium* L.

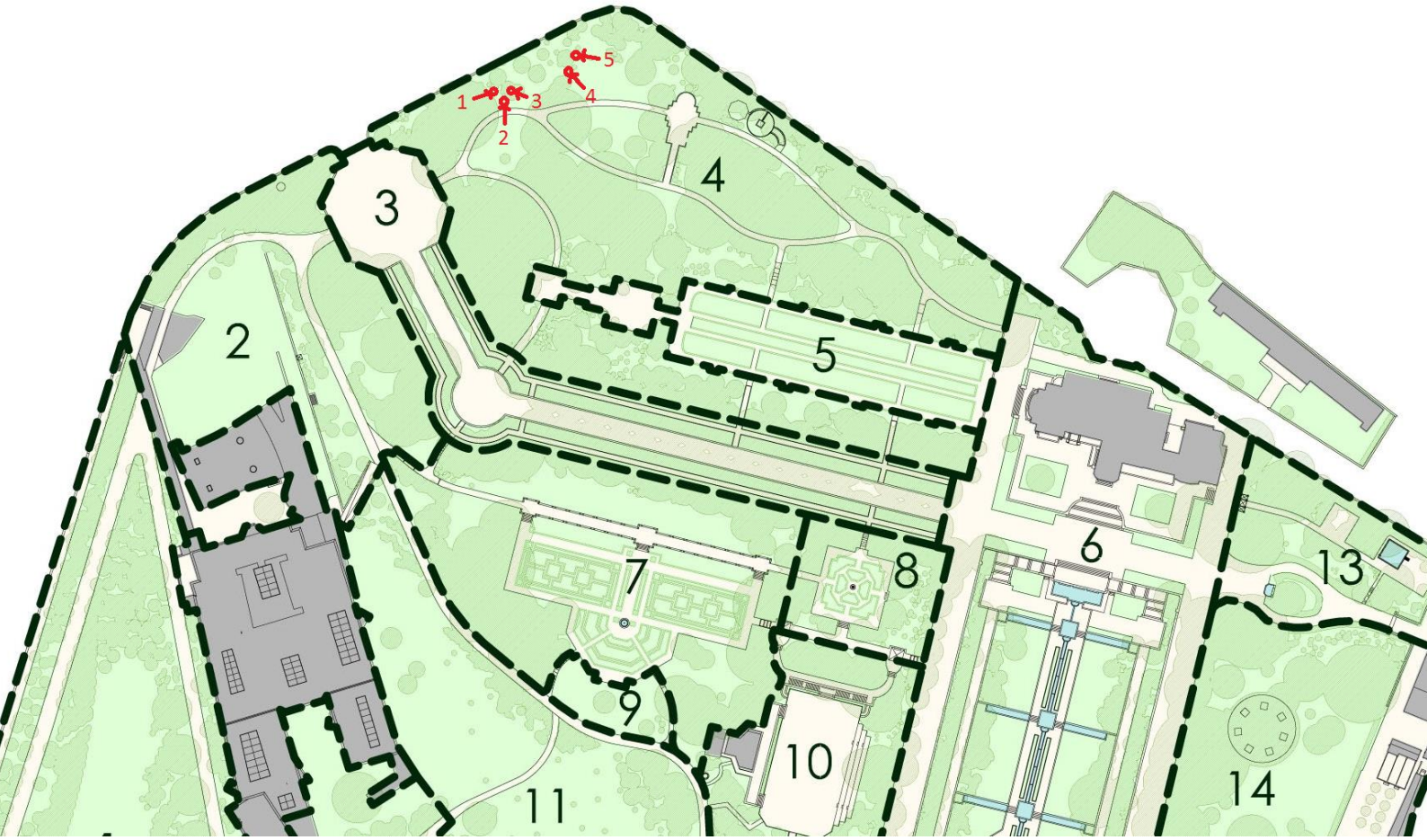
Comum: Azevinho

Local: Parque de Serralves

Número de identificação

Exemplar 1	Exemplar 2	Exemplar 3	Exemplar 4	Exemplar 5
11968	11969	11970	11981	11982

Localização dos exemplares no Parque: Bosque das Faias



Registo:

Data:	

Fases	É visível…	Exemplares 1	2	3	4	5
FL (Flores)	**[1] … o início da floração?** (A planta está coberta de botões de flores e as primeiras flores estão abertas?)					
	[2] … a floração intermédia? (Metade da planta, ou mais, está coberta de flores abertas e algumas das pétalas já começam a cair?)					
	[3] … a floração final? (A maior parte das flores está sem pétalas ou com pétalas secas?)					
FR (Frutos)	**[1] … o início da frutificação?** (Estão visíveis os primeiros frutos?)					
	[2] … o início da maturação dos frutos? (Os primeiros frutos imaturos estão a ficar avermelhados?)					
	[3] … a maturação dos 1os frutos? (A planta está coberta de frutos imaturos e os primeiros frutos exibem a cor vermelho-vivo – maduros?)					
	[4] … a maturação completa dos frutos? (Mais de metade dos frutos estão maduros e já começam a cair?)					

Fotos das diferentes fases:

Início da floração (macho)

Início da floração (fêmea)

Floração intermédia

Floração final

Início da frutificação

Início de maturação dos frutos

Maturação dos 1os frutos

Maturação completa dos frutos

Nome

Científico: *Laurus nobilis* L.

Comum: Loureiro

Local: Parque de Serralves

Número de identificação

Exemplar 1	Exemplar 2	Exemplar 3
5387	5505	5795

Localização dos exemplares no Parque: Clareira das Bétulas

Registo:

Data:	

		Exemplares		
Fases	**É visível…**	**1**	**2**	**3**
FL (Flores)	**[1] … o início da floração?** (A planta está coberta de botões de flores e as primeiras flores estão abertas?)			
	[2] … a floração intermédia? (Metade da planta, ou mais, está coberta de flores abertas e algumas já começam a cair ou a secar?)			
	[3] … a floração final? (A maior parte da planta está sem flores ou com flores secas?)			

Fotos das diferentes fases:

Início da floração

Floração intermédia

Floração final

Nome

Científico: *Prunus laurocerasus* L.

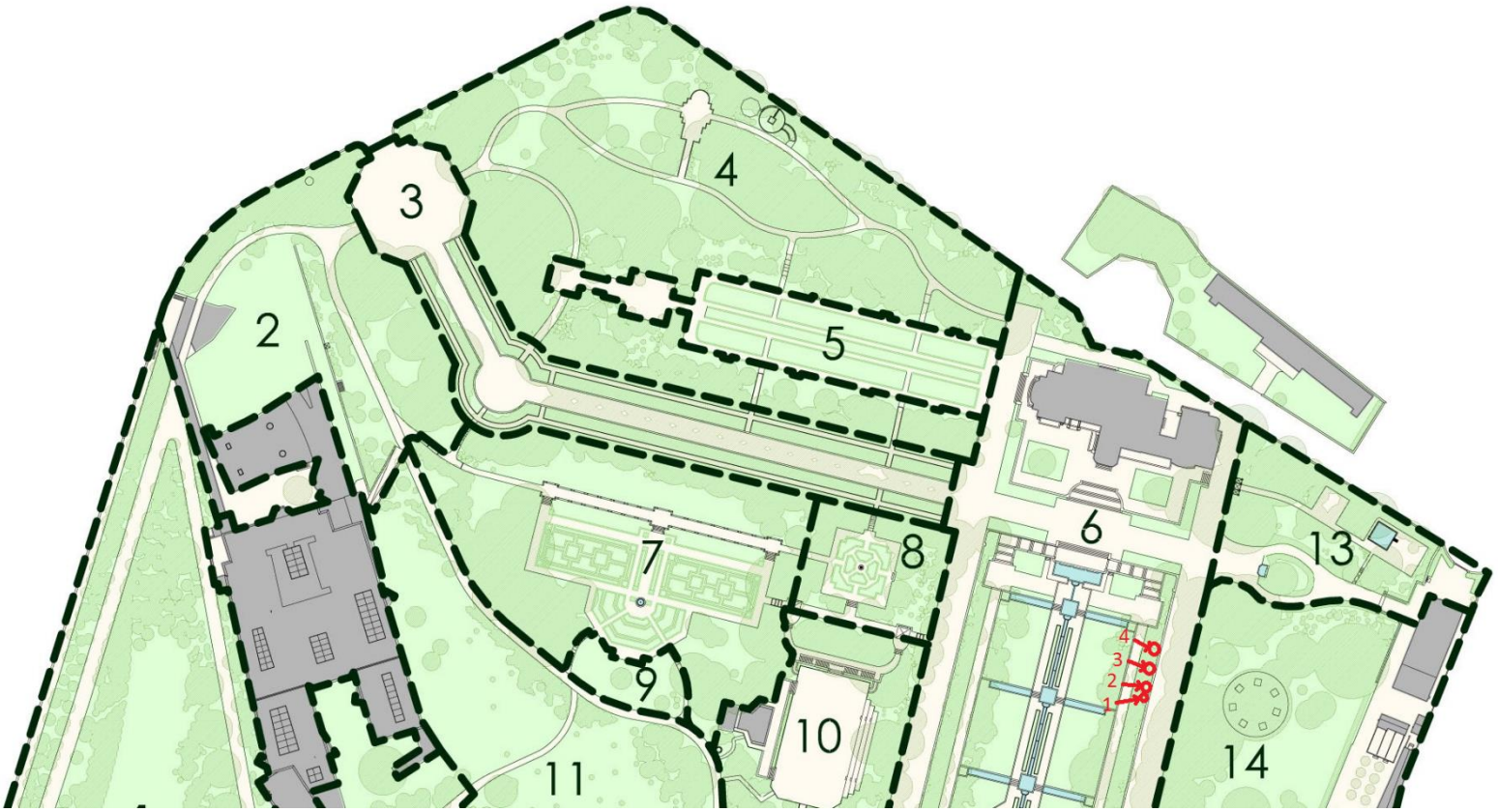
Comum: Loureiro-cerejeira

Local: Parque de Serralves

Número de identificação

Exemplar 1	Exemplar 2	Exemplar 3	Exemplar 4
3171	3169	3167	3165

Localização dos exemplares no Parque: Parterre Central



Registo:

Data:	

Fases	É visível…	Exemplares 1	2	3	4
FL (Flores)	**[1] … o início da floração?** (A planta está coberta de botões de flores e as primeiras flores estão abertas?)				
	[2] … a floração intermédia? (Metade da planta, ou mais, está coberta de flores abertas e algumas das pétalas já começam a cair?)				
	[3] … a floração final? (A maior parte das flores está sem pétalas ou com pétalas secas?)				
FR (Frutos)	**[1] … o início da frutificação?** (Estão visíveis os primeiros frutos?)				
	[2] … o início da maturação dos frutos? (Os primeiros frutos imaturos estão a ficar avermelhados?)				
	[3] … a maturação dos 1os frutos? (A planta está coberta de frutos imaturos e os primeiros frutos exibem a cor negro-lustrosa – maduros?)				
	[4] … a maturação completa dos frutos? (Mais de metade dos frutos estão maduros e já começam a cair?)				

Fotos das diferentes fases:

Início da floração

Floração intermédia

Floração final

Início da frutificação

Início de maturação dos frutos

Maturação dos 1os frutos

Maturação completa dos frutos

Nome

Científico: *Prunus lusitanica* L.

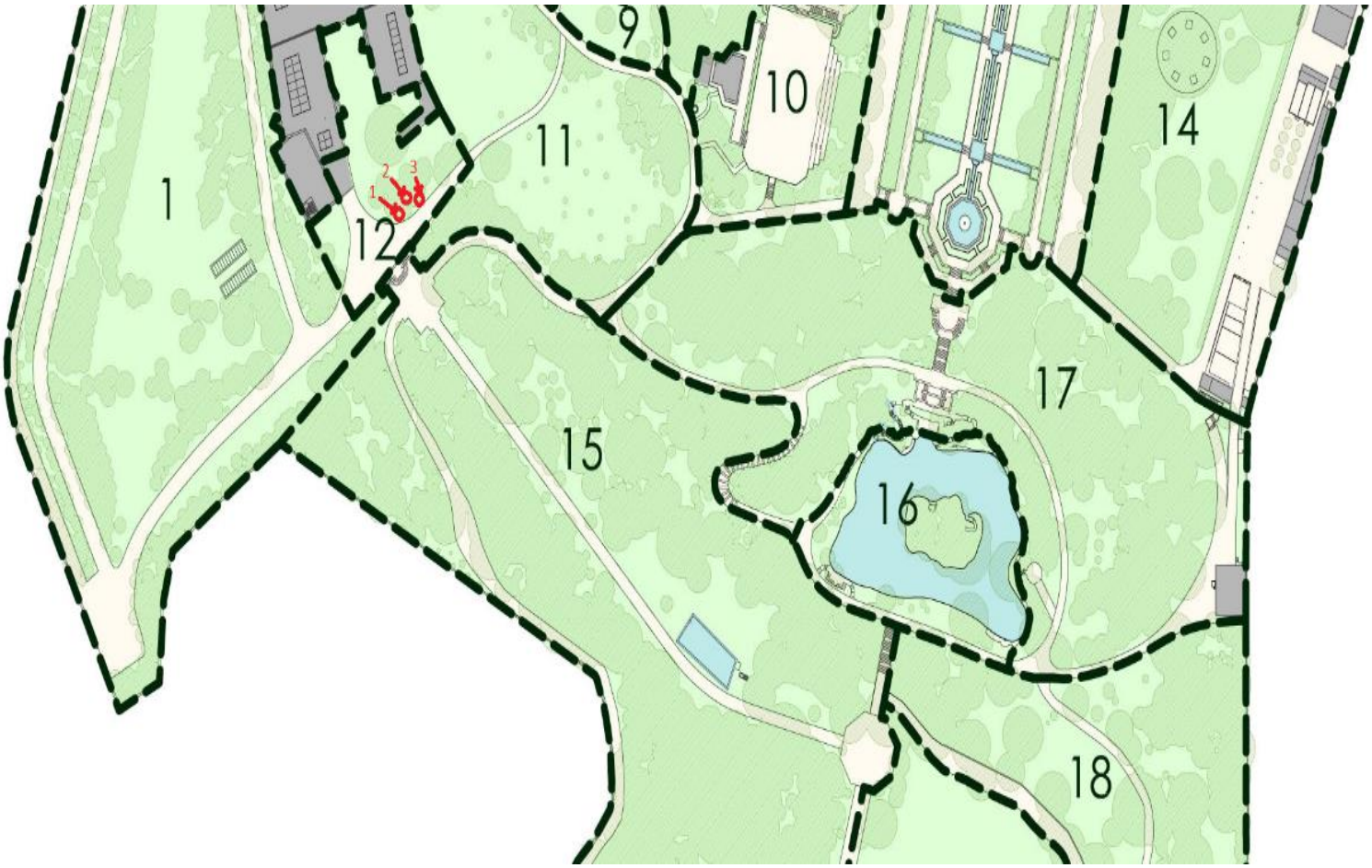
Comum: Azereiro; Loureiro-de-Portugal

Local: Parque de Serralves

Número de identificação

Exemplar 1	Exemplar 2	Exemplar 3
10893	10902	10906

Localização dos exemplares no Parque: Pátio do Ulmeiro



Registo:

Data:	

		Exemplares		
Fases	**É visível…**	**1**	**2**	**3**
FL (Flores)	**[1] … o início da floração?** (A planta está coberta de botões de flores e as primeiras flores estão abertas?)			
	[2] … a floração intermédia? (Metade da planta, ou mais, está coberta de flores abertas e algumas das pétalas já começam a cair?)			
	[3] … a floração final? (A maior parte das flores está sem pétalas ou com pétalas secas?)			
FR (Frutos)	**[1] … o início da frutificação?** (Estão visíveis os primeiros frutos?)			
	[2] … o início da maturação dos frutos? (Os primeiros frutos imaturos estão a ficar avermelhados?)			
	[3] … a maturação dos 1os frutos? (A planta está coberta de frutos imaturos e os primeiros frutos exibem a cor preta – maduros?)			
	[4] … a maturação completa dos frutos? (Mais de metade dos frutos estão maduros e já começam a cair?)			

Fotos das diferentes fases:

Início da floração

Floração intermédia

Floração final

Início da frutificação

Início de maturação dos frutos

Maturação dos 1os frutos

Maturação completa dos frutos

Nome

Científico: *Prunus persica* (L.) Batsch

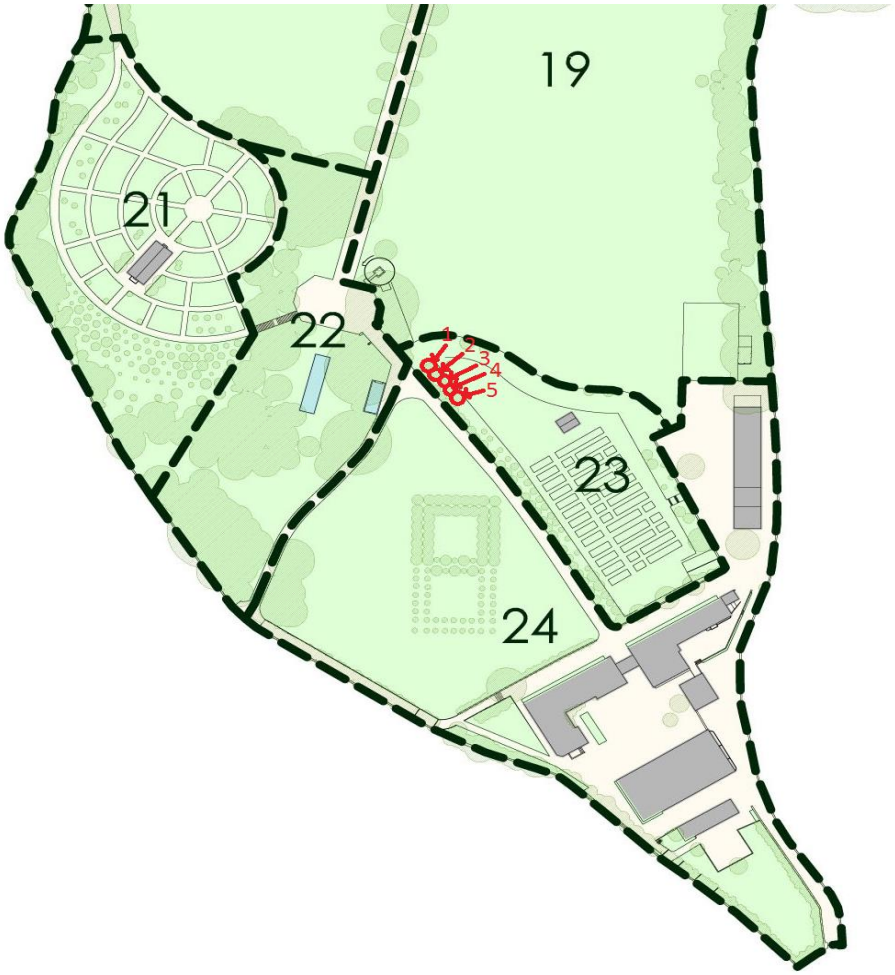
Comum: Pessegueiro

Local: Parque de Serralves

Número de identificação

Exemplar 1	Exemplar 2	Exemplar 3	Exemplar 4	Exemplar 5
2741	2867	2865	2743	2745

Localização dos exemplares no Parque: Horta Pedagógica



Registo:

Data:	

Fases	É visível…	Exemplares 1	2	3	4	5
FO (Folhas)	**[1] … o desenrolar das 1as folhas?** (As primeiras folhas estão totalmente desenroladas?)					
	[2] … o desenrolar das folhas? (Metade das folhas da planta estão já totalmente desenroladas?)					
FL (Flores)	**[1] … o início da floração?** (A planta está coberta de botões de flores e as primeiras flores estão abertas?)					
	[2] … a floração intermédia? (Metade da planta, ou mais, está coberta de flores abertas e algumas das pétalas já começam a cair?)					
	[3] … a floração final? (A maior parte das flores está sem pétalas ou com pétalas secas?)					
FR (Frutos)	**[1] … o início da frutificação?** (Estão visíveis os primeiros frutos (pêssegos)?)					
	[2] … o início da maturação dos frutos? (Os primeiros pêssegos imaturos estão a ficar alarenjados?)					
	[3] … a maturação dos 1os frutos? (A planta está coberta de pêssegos imaturos e os primeiros pêssegos exibem a cor amarela ou alaranjada – maduros?)					
	[4] … a maturação completa dos frutos? (Mais de metade dos pêssegos estão maduros e já começam a cair?)					
SE (Senescência)	**[1] … o início da coloração de Outono?** (Algumas das folhas estão a perder a sua cor verde original?)					
	[2] … a coloração de Outono? (Metade das folhas, ou mais, perderam a cor original?)					
	[3] … a queda outonal das folhas? (A planta já perdeu metade das folhas, ou mais?)					
	[4] … o fim da queda outonal das folhas? (A planta já quase não tem folhas?)					

Fotos das diferentes fases:

Desenrolar das 1as folhas

Desenrolar das folhas

Início da floração

Floração intermédia

Floração final

Início da frutificação

Início de maturação dos frutos

Maturação dos 1os frutos

Maturação completa dos frutos

Início de Coloração de Outono

Coloração de Outono

Queda outonal

Fim da queda outonal

Nome

Científico: *Prunus spinosa* L.

Comum: Abrunheiro

Local: Parque de Serralves

Número de identificação

Exemplar 1	Exemplar 2	Exemplar 3
14937	14936	14934

Localização dos exemplares no Parque: Clareira dos Teixos

Registo:

Data:	

		Exemplares		
Fases	**É visível…**	**1**	**2**	**3**
FO (Folhas)	**[1] … o desenrolar das 1ªs folhas?** (As primeiras folhas estão totalmente desenroladas?)			
	[2] … o desenrolar das folhas? (Metade das folhas da planta estão já totalmente desenroladas?)			
FL (Flores)	**[1] … o início da floração?** (A planta está coberta de botões de flores e as primeiras flores estão abertas?)			
	[2] … a floração intermédia? (Metade da planta, ou mais, está coberta de flores abertas e algumas das pétalas já começam a cair?)			
	[3] … a floração final? (A maior parte das flores está sem pétalas ou com pétalas secas?)			
FR (Frutos)	**[1] … o início da frutificação?** (Estão visíveis os primeiros frutos (abrunhos)?)			
	[2] … o início da maturação dos frutos? (Os primeiros abrunhos imaturos estão a ficar azulados?)			
	[3] … a maturação dos 1os frutos? (A planta está coberta de abrunhos imaturos e os primeiros abrunhos exibem a cor azul-escura – maduros?)			
	[4] … a maturação completa dos frutos? (Mais de metade dos abrunhos estão maduros e já começam a cair?)			
SE (Senescência)	**[1] … o início da coloração de Outono?** (Algumas das folhas estão a perder a sua cor verde original?)			
	[2] … a coloração de Outono? (Metade das folhas, ou mais, perderam a cor original?)			
	[3] … a queda outonal das folhas? (A planta já perdeu metade das folhas, ou mais?)			
	[4] … o fim da queda outonal das folhas? (A planta já quase não tem folhas?)			

Fotos das diferentes fases:

Desenrolar das 1as folhas

Desenrolar das folhas

Início da floração

Floração intermédia

Floração final

Início da fruificação

Início de maturação dos frutos

Maturação dos 1os frutos

Maturação completa dos frutos

Início de Coloração de Outono

Coloração de Outono

Queda outonal

Fim da queda outonal

Nome

Científico: *Quercus robur* L.

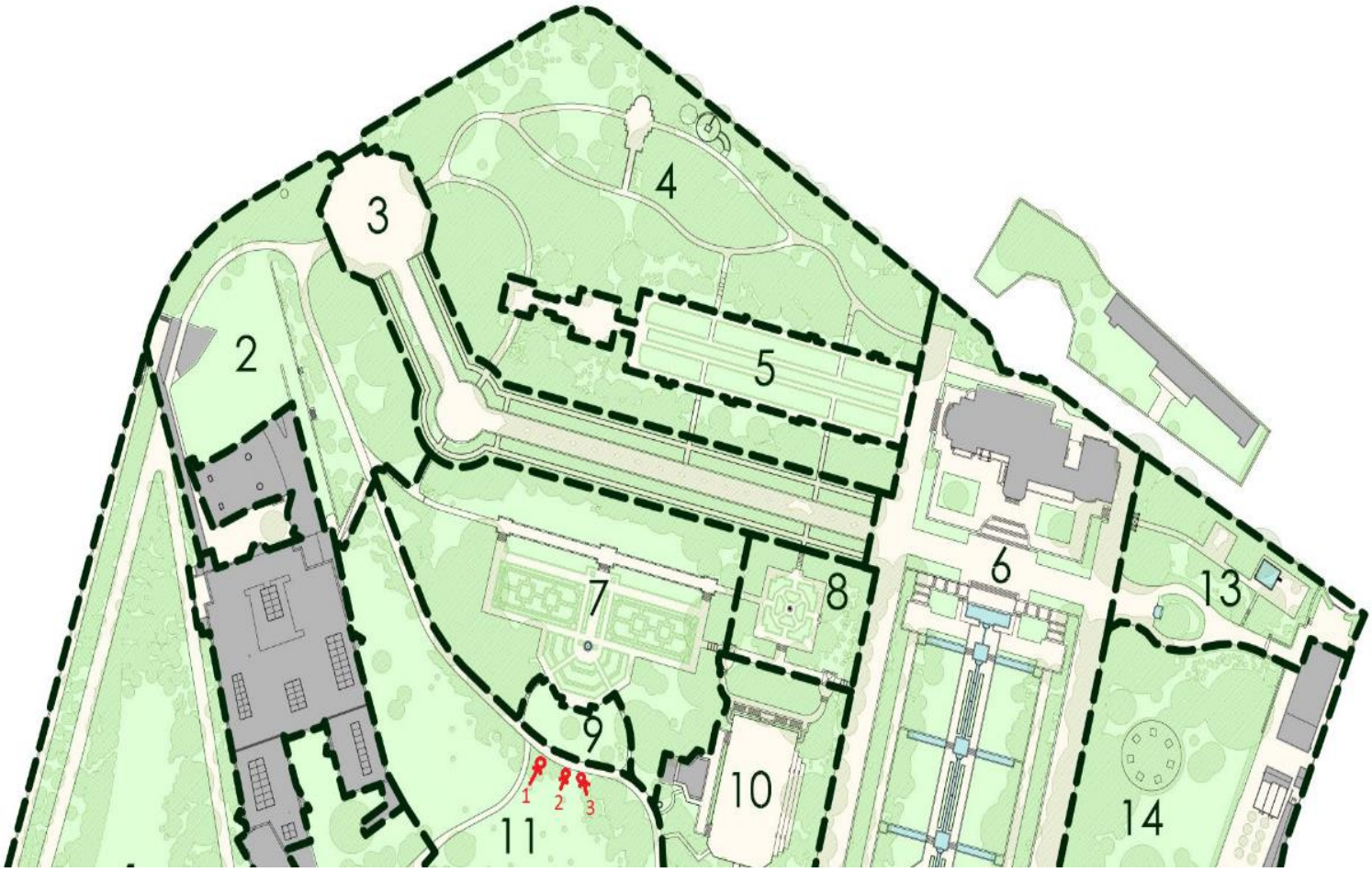
Comum: Carvalho-roble, Carvalho-alvarinho

Local: Parque de Serralves

Número de identificação

Exemplar 1	Exemplar 2	Exemplar 3
12474	12472	12471

Localização dos exemplares no Parque: Clareira dos Teixos



Registo:

Data:	

Fases	É visível…	Exemplares 1	2	3
FO (Folhas)	**[1] … o desenrolar das 1ªs folhas?** (As primeiras folhas estão totalmente desenroladas?)			
	[2] … o desenrolar das folhas? (Metade das folhas da planta estão já totalmente desenroladas?)			
FL (Flores)	**[2] … a floração intermédia?** (Metade da planta, ou mais, está coberta de flores abertas e algumas das pétalas já começam a cair?)			
FR (Frutos)	**[1] … o início da frutificação?** (Estão visíveis os primeiros frutos (bolotas)?)			
	[2] … o início da maturação dos frutos? (As primeiras bolotas imaturas estão a ficar acastanhadas?)			
	[3] … a maturação dos 1os frutos? (A planta está coberta de bolotas imaturas e as primeiras bolotas exibem a cor castanha – maduras?)			
	[4] … a maturação completa dos frutos? (Mais de metade dos bolotas estão maduras e já começam a cair?)			
SE (Senescência)	**[1] … o início da coloração de Outono?** (Algumas das folhas estão a perder a sua cor verde original?)			
	[2] … a coloração de Outono? (Metade das folhas, ou mais, perderam a cor original?)			
	[3] … a queda outonal das folhas? (A planta já perdeu metade das folhas, ou mais?)			
	[4] … o fim da queda outonal das folhas? (A planta já quase não tem folhas?)			

Fotos das diferentes fases:

Desenrolar das 1as folhas

Desenrolar das folhas

Floração intermédia

Início da frutificação

Início de maturação dos frutos

Maturação dos 1os frutos

Maturação completa dos frutos

Início de Coloração de Outono

Coloração de Outono

Queda outonal

Fim da queda outonal

Nome

Científico: *Rhaphiolepis umbellata* (Thunb.)

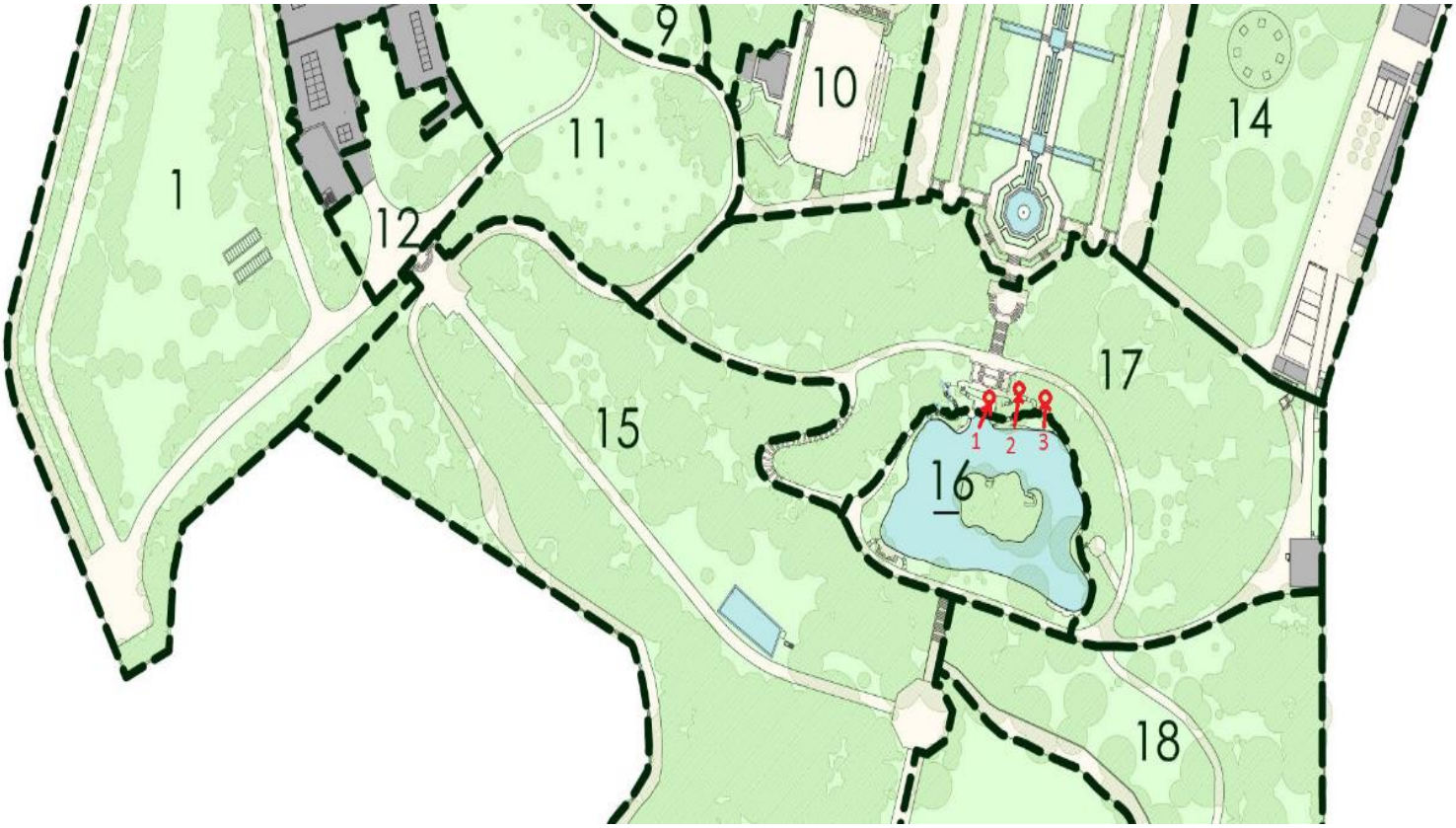
Comum: Rafiolépis

Local: Parque de Serralves

Número de identificação

Exemplar 1	Exemplar 2	Exemplar 3
10000	14070	14061

Localização dos exemplares no Parque: Bosque do Lago



Registo:

Data:	

		Exemplares		
Fases	**É visível…**	**1**	**2**	**3**
FL (Flores)	**[1] … o início da floração?** (A planta está coberta de botões de flores e as primeiras flores estão abertas?)			
	[2] … a floração intermédia? (Metade da planta, ou mais, está coberta de flores abertas e algumas das pétalas já começam a cair?)			
	[3] … a floração final? (A maior parte das flores está sem pétalas ou com pétalas secas?)			
FR (Frutos)	**[1] … o início da frutificação?** (Estão visíveis os primeiros frutos?)			
	[2] … o início da maturação dos frutos? (Os primeiros frutos imaturos estão a ficar azulados?)			
	[3] … a maturação dos 1os frutos? (A planta está coberta de frutos imaturos os primeiros frutos exibem a cor azul-escura – maduros?)			
	[4] … a maturação completa dos frutos? (Mais de metade dos frutos estão maduros e já começam a cair?)			

Fotos das diferentes fases:

Início da floração

Floração intermédia

Floração final

Início da frutificação

Início de maturação dos frutos

Maturação dos 1os frutos

Maturação completa dos frutos

Nome

Científico: *Taxus baccata* L.

Comum: Teixo

Local: Parque de Serralves

Número de identificação

Exemplar 1	Exemplar 2	Exemplar 3
14433	14412	14413

Localização dos exemplares no Parque: Lugar da Oliveira; Roseiral

Registo:

Data:	

		Exemplares		
Fases	**É visível…**	**1**	**2**	**3**
CO (Cones)	**[1] … o aparecimento dos 1os cones femininos não maduros?** (Os primeiros cones femininos são visíveis?)			
	[2] … a maturação dos 1os cones femininos? (Os primeiros cones femininos estão rodeados por arilos carnudos e vermelhos - maduros?)			
	[3] … a maturação completa dos cones femininos? (Mais de metade dos arilos estão maduros e já começam a cair?)			

Fotos das diferentes fases:

Aparecimento dos 1os cones femininos não maduros

Maturação dos 1os cones femininos

Maturação completa

Nome

Científico: *Tibouchina urvilleana* (de Candolle) Cogniaux

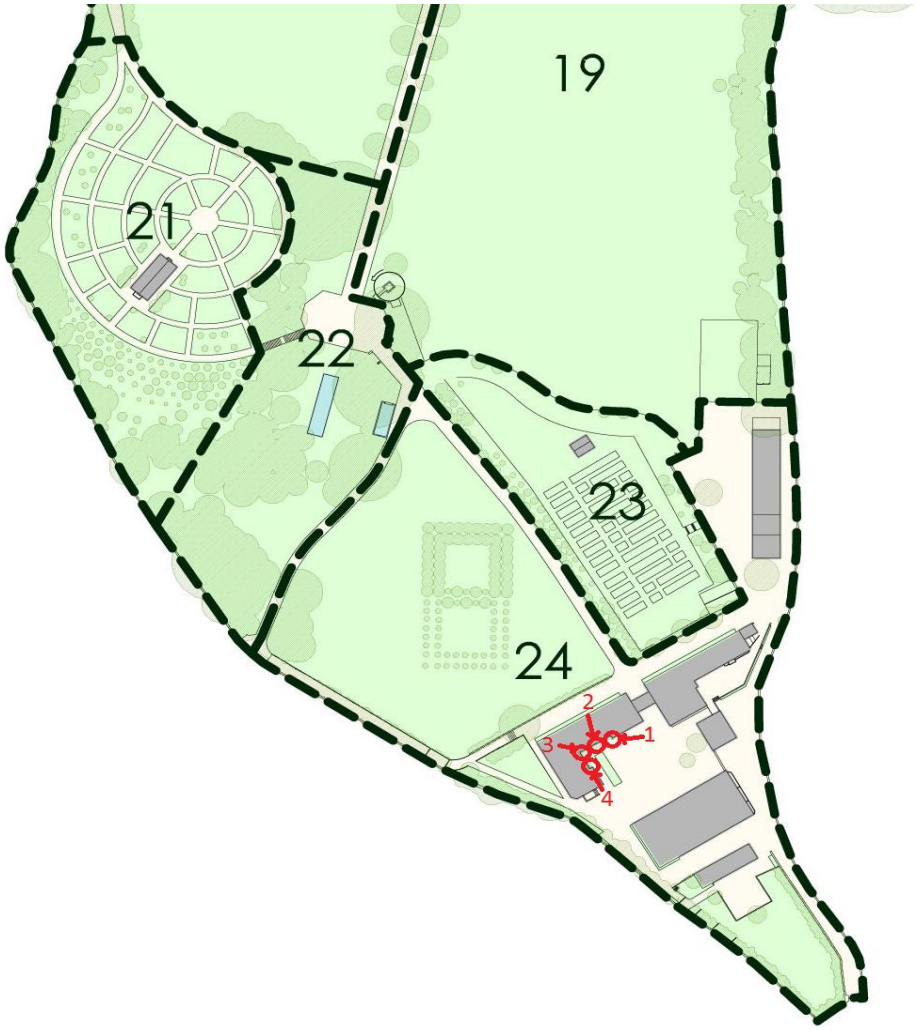
Comum: Tiboquina

Local: Parque de Serralves

Número de identificação

Exemplar 1	Exemplar 2	Exemplar 3	Exemplar 4
13729	13730	13731	13732

Localização dos exemplares no Parque: Assento Agrícola do Mata-Sete



Registo:

Data:	

Fases	É visível…	Exemplares 1	2	3	4
FL (Flores)	**[1] … o início da floração?** (A planta está coberta de botões de flores e algumas das flores estão abertas?)				
	[2] … a floração intermédia? (Metade da planta, ou mais, está coberta de flores abertas e algumas das pétalas já começam a cair?)				
	[3] … a floração final? (A maior parte das flores está sem pétalas ou com pétalas secas?)				
FR (Frutos)	**[1] … o início da frutificação?** (Estão visíveis alguns frutos imaturos?)				
	[2] … o início da maturação dos frutos? (Os frutos imaturos estão a ficar avermelhados?)				
	[3] … a maturação dos 1os frutos? (A planta está coberta de frutos imaturos e alguns frutos que exibem a cor castanho-escura – maduros?)				
	[4] … a maturação completa dos frutos? (Mais de metade dos frutos estão maduros e já começam a cair?)				

Fotos das diferentes fases:

Início da floração

Floração intermédia

Floração final

Início da frutificação

Início de maturação dos frutos

Maturação dos frutos

Maturação completa dos frutos

Nome

Científico: *Viburnum tinus* L.

Comum: Folhado

Local: Parque de Serralves

Número de identificação

Exemplar 1	Exemplar 2	Exemplar 3	Exemplar 4	Exemplar 5
11933	11935	11936	11938	11940

Localização dos exemplares no Parque: Bosque das Faias

Registo:

Data:	

		Exemplares				
Fases	**É visível…**	**1**	**2**	**3**	**4**	**5**
FL (Flores)	**[1] … o início da floração?** (A planta está coberta de botões de flores e algumas das flores estão abertas?)					
	[2] … a floração intermédia? (Metade da planta, ou mais, está coberta de flores abertas e algumas das pétalas já começam a cair?)					
	[3] … a floração final? (A maior parte das flores está sem pétalas ou com pétalas secas?)					
FR (Frutos)	**[1] … o início da frutificação?** (Estão visíveis alguns frutos imaturos?)					
	[2] … o início da maturação dos frutos? (Os frutos imaturos estão a ficar avermelhados?)					
	[3] … a maturação dos 1os frutos? (A planta está coberta de frutos imaturos e alguns frutos exibem a cor azul-metálica – maduros?)					
	[4] … a maturação completa dos frutos? (Mais de metade dos frutos estão maduros e já começam a cair?)					

Fotos das diferentes fases:

Início da floração

Floração intermédia

Floração final

Início da frutificação

Início de maturação dos frutos

Maturação dos frutos

Maturação completa dos frutos

Appendix IX – Phenological monitoring guide of “Serralves em Flora”

Serralves em Flora - Manual da Monitorização Fenológica

Guia de boas práticas para o registo de observações fenológicas da flora do Parque de Serralves

Conteúdo

1. Introdução

A **fenologia** é a ciência que estuda os eventos cíclicos dos ciclos de vida de alguns organismos (como plantas, animais, micróbios). Estes eventos cíclicos têm o nome de **fenofases** e estas diferem consoante o organismo a observar. Para este projeto os organismos em estudo são plantas por isso as fenofases focam-se nos eventos relacionados com as folhas, as flores e os frutos.

O estudo das fenofases realiza-se através de observações periódicas das espécies de interesse, registando as datas dessas observações e as fenofases que estão a decorrer nessa altura. Por outras palavras, o estudo é realizado através da **monitorização**, utilizando fichas de monitorização pré-definidas para as espécies selecionadas para o estudo. Também é possível utilizar a fotografia como apoio à observação.

As condições ambientais condicionam a fenologia dos organismos, criando alterações: 1) a longo prazo, o que afeta as gerações futuras das espécies afetadas, e 2) a curto prazo, o que afeta o ciclo de vida do organismo. Essas alterações vão afetar estes organismos e todos os outros que estão interligados a estes, alterando o equilíbrio natural do ecossistema e de outros interligados a este. O desequilíbrio do ecossistema pode levar ao desaparecimento de uma das espécies cruciais, levando posteriormente ao desaparecimento das restantes (exemplo: equilíbrio entre plantas e polinizadores, necessários à reprodução de muitas espécies de plantas). **O estudo da fenologia** permite ver até que ponto um sistema é afetado e alterado pelas condições ambientais a que está sujeito e, ao estudarmos estas alterações, será possível observar o padrão que se está a formar nos ciclos de vida e fazer previsões futuras para a adaptação a estas alterações ser possível.

Existem espalhados pelo mundo vários programas de monitorização fenológica. Estes programas permitem aos cidadãos tornarem-se voluntários e contribuírem para o estudo fenológico através das suas observações e registos que serão utilizados por cientistas nos seus estudos. Esta parceria entre voluntários e cientistas denomina-se **“citizen science”,** ou seja ciência feita pelo cidadão, e tem sido cada vez mais utilizada, pois permite recolher uma maior quantidade de dados num menor intervalo de tempo.

Serralves tem vindo a desenvolver diversas iniciativas de “citizen science”. O projeto **“Serralves em Flora”,** direcionado para as árvores e arbustos, visa o envolvimento dos visitantes com o património florístico do Parque, através da monitorização fenológica das espécies selecionadas para este estudo.

Este manual servirá como um guia de boas práticas, direcionado aos colaboradores de Serralves que venham a ter contacto com o projeto. O seu objetivo é prestar as informações necessárias sobre o projeto Serralves em Flora (o que é, quais os seus fundamentos, o que estuda, como se estuda e quais os cuidados a ter), para que este possa ter sucesso e seja continuado após ser implementado.

2. Projeto Serralves em Flora

O projeto **Serralves em Flora** consiste num projeto de monitorização fenológica da flora que existe no Parque de Serralves e tem como objetivo estudar o efeito que as alterações climáticas na flora do parque.

Para se proceder ao estudo fenológico do parque, 22 espécies de plantas (árvores e arbustos), das 201 presentes do parque, foram selecionadas para serem as espécies a monitorizar.

Para cada espécie foi criada uma ficha de monitorização personalizada. Cada ficha contém uma **parte introdutória** (introdução ao projeto e às técnicas de monitorização a cumprir), uma **ficha técnica da espécie** (denominação comum e científica da espécie, número de exemplares a monitorizar e localização de cada um no parque), **tabela de registos** (data da observação, nome, descrição e código para cada fenofases selecionada, número de exemplares e respetivo local para preenchimento dos dados), e por último, **guia fotográfico** (fotografias de cada fenofase a observar). As fichas estarão disponíveis na plataforma Biodiversidade e Ambiente, no módulo de Serralves em Flora.

Pretende-se que seja o público a monitorizar as espécies selecionadas para o estudo utilizando as fichas de monitorização criadas e câmaras digitais. O público deve seguir os passos apresentados nas fichas de monitorização e, durante eventos, os responsáveis por este projeto deverão criar uma pequena sessão de formação com o público interessado, explicando brevemente o projeto Serralves em Flora e o modo correto de monitorizar as espécies.

Após preencher a tabela, o visitante deve registar os dados e fotografias na plataforma Serralves em Flora. Os dados serão colocados numa base de dados, onde serão avaliados pelo controlo de qualidade. As fotografias registadas serão utilizadas para determinar se os dados registados pelo observador estão corretos ou não. Os dados que passarem este teste de qualidade serão tratados estatisticamente, para determinar o efeito das alterações climáticas ao longo dos anos.

Para informar o público dos resultados obtidos, estes serão apresentados em forma de tabelas e gráficos na plataforma “Serralves em Flora”.

3. Guia das espécies e fenofases

3.1. Espécies

Foram selecionadas 22 espécies, das 201 totais, para serem monitorizadas. Para esta seleção, 7 critérios foram desenvolvidos, utilizando como base os critérios utilizados por programas de monitorização fenológica. Os critérios foram: **1) forma de vida** (árvore, arbusto ou herbácea); **2) tendência biogeográfica** (clima temperado, mediterrâneo, continental ou subtropical); **3) origem** (espécie nativa ou exótica); **4) carácter invasivo** (espécie invasiva ou não invasiva); **5) estruturas presentes e visibilidade** (folhas, flores e frutos); **6) número de indivíduos** (entre 3 a 5); **7) estado de conservação**; **8) proximidade entre indivíduos e acesso** (indivíduos mais próximos e de fácil acesso).

Nome científico	**Nome comum**	**Forma de vida**	**Grupo**	**Flores**	**Frutos**
Amelanchier ovalis Medik.	--------	Árvore/Arbusto	Decídua	Corimbos	Pomos
Arbutus unedo L.	Medronheiro	Árvore/Arbusto	Perene	Panículas	Medronhos (bagas)
Buxus sempervirens L.	Buxo	Arbusto	Perene	Glomérulos	Cápsulas
Citrus deliciosa Tenor	Tangerineira	Árvore	Perene	Solitárias	Tangerinas (hesperídeos)
Citrus limon (L.) Burm.fil.	Limoeiro	Árvore	Perene	Solitárias	Limões (hesperídeos)
Citrus sinensis (L.) Osbeck	Laranjeira	Árvore	Perene	Solitárias	Laranjas (hesperídeos)
Corylus avellana L.	Aveleira	Árvore/Arbusto	Decídua	Amentilhos	Avelãs (aquénios)
Crataegus monogyna Jacq.	Pilriteiro	Árvore/Arbusto	Decídua	Corimbos	Pirenários
Cydonia oblonga L.	Marmeleiro	Árvore	Decídua	Solitárias	Marmelos (pomos)

Gardenia jasminoides J. Ellis	Gardénia	Arbusto	Perene	Solitárias	Bagas
Ginkgo biloba L.	Ginkgo	Árvore	Decídua	Racimos	Drupas
Ilex aquifolium L.	Azevinho	Árvore/Arbusto	Perene	Cachos	Drupas
Laurus nobilis L.	Loureiro	Árvore/Arbusto	Perene	Glomérulos	Bagas
Prunus laurocerasus L.	Loureiro-cerejeira	Árvore/Arbusto	Perene	Cachos	Drupas
Prunus lusitanica L.	Loureiro-de-Portugal	Árvore	Perene	Cachos	Drupas
Prunus persica (L.) Batsch	Pessegueiro	Árvore	Decídua	Solitárias	Pêssegos (drupas)
Prunus spinosa L.	Abrunheiro	Árvore	Decídua	Fascículos	Abrunhos (drupas)
Quercus robur L.	Carvalho-alvarinho	Árvore	Decídua	Amentilhos	Bolotas (glandes)
Rhaphiolepis umbellata (Thunb.) Makino	Rafiolépis	Arbusto	Perene	Panículas	Pomos
Taxus baccata L.	Teixo	Árvore	Conífera	Estróbilos (masculinos) / Cones (femininos)	Arilos (pseudo-fruto)
Tibouchina urvilleana (de Candolle) Cogniaux	Tiboquina	Árvore/Arbusto	Tardiamente Decídua	Cimeiras	Cápsulas
Viburnum tinus L.	Folhado	Arbusto	Perene	Corimbos	Drupas

3.2. Fenofases gerais

Foram selecionadas um total de 16 fenofases para observar, no entanto, cada espécie tem a sua própria seleção de fenofases. Estas 16 fenofases foram o resultado de uma pesquisa feita a diversas listagens de fenofases estudadas em programas fenológicos e da seleção das fases mais adequadas para o público observar.

Fenofases	Perenes	Decíduas	Coníferas
Desenrolar das 1as folhas		X	
Desenrolar das folhas		X	
Início da floração	X	X	
Floração intermédia	X	X	
Floração final	X	X	
Início da frutificação	X	X	
Aparecimento dos 1os cones femininos não maduros			X
Maturação dos 1os cones femininos			X
Início de maturação dos frutos	X	X	
Maturação dos 1os frutos	X	X	
Maturação completa dos frutos	X	X	
Maturação completa dos cones femininos			X
Início da coloração de Outono		X	
Coloração de Outono		X	
Queda outonal das folhas		X	
Fim da queda outonal das folhas		X	

3.3. Fenofases de cada espécie

Amelanchier ovalis Medik.

Código	Fenofase	Descrição
FO - 1	Desenrolar das 1as folhas	As primeiras folhas estão totalmente desenroladas.
FO - 2	Desenrolar das folhas	Metade das folhas da planta estão já totalmente desenroladas.
FL - 1	Início da floração	A planta está coberta de botões de flores e as primeiras flores estão abertas.
FL - 2	Floração intermédia	Metade da planta, ou mais, está coberta de flores abertas e algumas das pétalas já começam a cair.
FL - 3	Floração final	A maior parte das flores está sem pétalas ou com pétalas secas.
FR - 1	Início da frutificação	Estão visíveis os primeiros frutos.
FR - 2	Início da maturação dos frutos	Os primeiros frutos imaturos estão a ficar avermelhados.
FR - 3	Maturação dos 1os frutos	A planta está coberta de frutos imaturos e os primeiros frutos exibem a cor negro-azulada – maduros.
FR - 4	Maturação completa dos frutos	Mais de metade dos frutos estão maduros e já começam a cair.
SE - 1	Início da coloração de Outono	Algumas das folhas estão a perder a sua cor verde original.
SE - 2	Coloração de Outono	Metade das folhas, ou mais, perderam a cor original.
SE - 3	Queda outonal das folhas	A planta já perdeu metade das folhas, ou mais.
SE - 4	Fim da queda outonal das folhas	A planta já quase não tem folhas.

Arbutus unedo L.

(Medronheiro)

Código	Fenofase	Descrição
FL - 1	Início da floração	A planta está coberta de botões de flores e as primeiras flores estão abertas.
FL - 2	Floração intermédia	Metade da planta, ou mais, está coberta de flores abertas e algumas já começam a cair.
FL - 3	Floração final	A maior parte das flores está sem flores.
FR - 1	Início da frutificação	Estão visíveis os primeiros frutos (medronhos).
FR - 2	Início da maturação dos frutos	Os primeiros medronhos imaturos estão a ficar avermelhados.
FR - 3	Maturação dos 1os frutos	A planta está coberta de medronhos imaturos e os primeiros medronhos exibem a cor vermelha – maduros.
FR - 4	Maturação completa dos frutos	Mais de metade dos medronhos estão maduros e já começam a cair.

Buxus sempervirens L.

(Buxo)

Código	Fenofase	Descrição
FL - 1	Início da floração	A planta está coberta de botões de flores e as primeiras flores estão abertas.
FL - 2	Floração intermédia	Metade da planta, ou mais, está coberta de flores abertas e algumas já começam a cair.
FL - 3	Floração final	A maior parte das flores está sem flores
FR - 1	Início da frutificação	Estão visíveis os primeiros frutos.
FR - 2	Início da maturação dos frutos	Os primeiros frutos imaturos estão a ficar acastanhados.
FR - 3	Maturação dos 1os frutos	A planta está coberta de frutos imaturos e os primeiros frutos exibem a cor castanha – maduros.
FR - 4	Maturação completa dos frutos	Mais de metade dos frutos estão maduros e já começam a abrir.

Citrus deliciosa Tenor

(Tangerineira “Montenegrina”)

Código	Fenofase	Descrição
FL - 1	Início da floração	A planta está coberta de botões de flores e as primeiras flores estão abertas.
FL - 2	Floração intermédia	Metade da planta, ou mais, está coberta de flores abertas e algumas das pétalas já começam a cair.
FL - 3	Floração final	A maior parte das flores está sem pétalas ou com pétalas secas.
FR - 1	Início da frutificação	Estão visíveis os primeiros frutos (tangerinas).
FR - 2	Início da maturação dos frutos	As primeiras tangerinas imaturas estão a ficar alaranjadas.
FR - 3	Maturação dos 1os frutos	A planta está coberta de tangerinas imaturas e as primeiras tangerinas exibem a cor laranja-viva – maduras.
FR - 4	Maturação completa dos frutos	Mais de metade das tangerinas estão maduras e já começam a cair.

Citrus limon (L.) Burm.fil.

(Limoeiro)

Código	Fenofase	Descrição
FL - 1	Início da floração	A planta está coberta de botões de flores e as primeiras flores estão abertas.
FL - 2	Floração intermédia	Metade da planta, ou mais, está coberta de flores abertas e algumas das pétalas já começam a cair.
FL - 3	Floração final	A maior parte das flores está sem pétalas ou com pétalas secas.

FR - 1	Início da frutificação	Estão visíveis os primeiros frutos (limões).
FR - 2	Início da maturação dos frutos	Os primeiros limões imaturos estão a ficar amarelados.
FR - 3	Maturação dos 1os frutos	A planta está coberta de limões imaturos e os primeiros limões exibem a cor amarela – maduros.
FR - 4	Maturação completa dos frutos	Mais de metade dos limões estão maduros e já começam a cair.

Citrus sinensis (L.) Osbeck

(Laranjeira)

Código	Fenofase	Descrição
FL - 1	Início da floração	A planta está coberta de botões de flores e as primeiras flores estão abertas.
FL - 2	Floração intermédia	Metade da planta, ou mais, está coberta de flores abertas e algumas das pétalas já começam a cair.
FL - 3	Floração final	A maior parte das flores está sem pétalas ou com pétalas secas.
FR - 1	Início da frutificação	Estão visíveis os primeiros frutos (laranjas).
FR - 2	Início da maturação dos frutos	As primeiras laranjas imaturas estão a ficar alaranjadas.
FR - 3	Maturação dos 1os frutos	A planta está coberta de laranjas imaturas e as primeiras laranjas exibem a cor laranja – maduras.
FR - 4	Maturação completa dos frutos	Mais de metade das laranjas estão maduras e já começam a cair.

Corylus avellana L.

(Aveleira)

Código	Fenofase	Descrição
FO - 1	Desenrolar das 1as folhas	As primeiras folhas estão totalmente desenroladas.
FO - 2	Desenrolar das folhas	Metade das folhas da planta estão já totalmente desenroladas.
FR - 1	Início da frutificação	Estão visíveis os primeiros frutos (avelãs).
FR - 2	Início da maturação dos frutos	As primeiras avelãs imaturas estão a ficar acastanhadas.
FR - 3	Maturação dos 1os frutos	A planta está coberta de avelãs imaturas e as primeiras avelãs exibem a cor castanha – maduras.
FR - 4	Maturação completa dos frutos	Mais de metade das avelãs estão maduras e já começam a cair.
SE - 1	Início da coloração de Outono	Algumas das folhas estão a perder a sua cor verde original.
SE - 2	Coloração de Outono	Metade das folhas, ou mais, perderam a cor original.
SE - 3	Queda outonal das folhas	A planta já perdeu metade das folhas, ou mais.
SE - 4	Fim da queda outonal das folhas	A planta já quase não tem folhas.

Crataegus monogyna Jacq.

(Pilriteiro)

Código	Fenofase	Descrição
FO - 1	Desenrolar das 1as folhas	As primeiras folhas estão totalmente desenroladas.

FO - 2	Desenrolar das folhas	Metade das folhas da planta estão já totalmente desenroladas.
FL - 1	Início da floração	A planta está coberta de botões de flores e as primeiras flores estão abertas.
FL - 2	Floração intermédia	Metade da planta, ou mais, está coberta de flores abertas e algumas das pétalas já começam a cair.
FL - 3	Floração final	A maior parte das flores está sem pétalas ou com pétalas secas.
FR - 1	Início da frutificação	Estão visíveis os primeiros frutos.
FR - 2	Início da maturação dos frutos	Os primeiros frutos imaturos estão a ficar avermelhados.
FR - 3	Maturação dos 1os frutos	A planta está coberta de frutos imaturos e os primeiros frutos exibem a cor vermelho-vivo – maduros.
FR - 4	Maturação completa dos frutos	Mais de metade dos frutos estão maduros e já começam a cair.
SE - 1	Início da coloração de Outono	Algumas das folhas estão a perder a sua cor verde original.
SE - 2	Coloração de Outono	Metade das folhas, ou mais, perderam a cor original.
SE - 3	Queda outonal das folhas	A planta já perdeu metade das folhas, ou mais.
SE - 4	Fim da queda outonal das folhas	A planta já quase não tem folhas.

Cydonia oblonga L.

(Marmeleiro)

Código	Fenofase	Descrição

FO - 1	Desenrolar das 1as folhas	As primeiras folhas estão totalmente desenroladas.
FO - 2	Desenrolar das folhas	Metade das folhas da planta estão já totalmente desenroladas.
FL - 1	Início da floração	A planta está coberta de botões de flores e as primeiras flores estão abertas.
FL - 2	Floração intermédia	Metade da planta, ou mais, está coberta de flores abertas e algumas das pétalas já começam a cair.
FL - 3	Floração final	A maior parte das flores está sem pétalas ou com pétalas secas.
FR - 1	Início da frutificação	Estão visíveis os primeiros frutos (marmelos).
FR - 2	Início da maturação dos frutos	Os primeiros marmelos imaturos estão a ficar amarelados.
FR - 3	Maturação dos 1os frutos	A planta está coberta de marmelos imaturos e os primeiros marmelos exibem a cor amarela – maduros.
FR - 4	Maturação completa dos frutos	Mais de metade dos marmelos estão maduros e já começam a cair.
SE - 1	Início da coloração de Outono	Algumas das folhas estão a perder a sua cor verde original.
SE - 2	Coloração de Outono	Metade das folhas, ou mais, perderam a cor original.
SE - 3	Queda outonal das folhas	A planta já perdeu metade das folhas, ou mais.
SE - 4	Fim da queda outonal das folhas	A planta já quase não tem folhas.

Gardenia jasminoides J. Ellis

(Gardenia)

Código	Fenofase	Descrição
FL - 1	Início da floração	A planta está coberta de botões de flores e as primeiras flores estão abertas.
FL - 2	Floração intermédia	Metade da planta, ou mais, está coberta de flores abertas e algumas das pétalas já começam a cair.
FL - 3	Floração final	A maior parte das flores está sem pétalas ou com pétalas secas.
FR - 1	Início da frutificação	Estão visíveis os primeiros frutos.
FR - 2	Início da maturação dos frutos	Os primeiros frutos imaturos estão a ficar amareladao.
FR - 3	Maturação dos 1os frutos	A planta está coberta de frutos imaturos e os primeiros frutos exibem a cor laranja-vivo – maduros.
FR - 4	Maturação completa dos frutos	Mais de metade dos frutos estão maduros e já começam a cair.

Ginkgo biloba L.

(Ginkgo)

Código	Fenofase	Descrição
FO - 1	Desenrolar das 1as folhas	As primeiras folhas estão totalmente desenroladas.
FO - 2	Desenrolar das folhas	Metade das folhas da planta estão já totalmente desenroladas.
FL - 1	Início da floração	A planta está coberta de botões de flores e as primeiras flores estão abertas (macho/fêmea).

FL - 3	Floração final	A maior parte das flores está sem flores ou com flores secas.
FR - 1	Início da frutificação	Estão visíveis os primeiros frutos.
FR - 2	Início da maturação dos frutos	Os primeiros frutos imaturos estão a ficar acastanhados.
FR - 3	Maturação dos 1os frutos	A planta está coberta de frutos imaturos e os primeiros frutos exibem a cor amarelo-acastanhada – maduros.
FR - 4	Maturação completa dos frutos	Mais de metade dos frutos estão maduros e já começam a cair.
SE - 1	Início da coloração de Outono	Algumas das folhas estão a perder a sua cor verde original.
SE - 2	Coloração de Outono	Metade das folhas, ou mais, perderam a cor original.
SE - 3	Queda outonal das folhas	A planta já perdeu metade das folhas, ou mais.
SE - 4	Fim da queda outonal das folhas	A planta já quase não tem folhas.

Ilex aquifolium L.

(Azevinho)

Código	Fenofase	Descrição
FL - 1	Início da floração	A planta está coberta de botões de flores e as primeiras flores estão abertas.
FL - 2	Floração intermédia	Metade da planta, ou mais, está coberta de flores abertas e algumas das pétalas já começam a cair.
FL - 3	Floração final	A maior parte das flores está sem pétalas ou com pétalas secas.
FR - 1	Início da frutificação	Estão visíveis os primeiros frutos.
FR - 2	Início da maturação dos frutos	Os primeiros frutos imaturos estão a ficar avermelhados.

FR - 3	Maturação dos 1os frutos	A planta está coberta de frutos imaturos e os primeiros frutos exibem a cor vermelho-vivo – maduros.
FR - 4	Maturação completa dos frutos	Mais de metade dos frutos estão maduros e já começam a cair.

Laurus nobilis L.

(Loureiro)

Código	Fenofase	Descrição
FL - 1	Início da floração	A planta está coberta de botões de flores e as primeiras flores estão abertas.
FL - 2	Floração intermédia	Metade da planta, ou mais, está coberta de flores abertas e algumas já começam a cair.
FL - 3	Floração final	A maior parte das flores está sem flores ou com flores secas.

Prunus laurocerasus L.

(Loureiro-cerejeira)

Código	Fenofase	Descrição
FL - 1	Início da floração	A planta está coberta de botões de flores e as primeiras flores estão abertas.
FL - 2	Floração intermédia	Metade da planta, ou mais, está coberta de flores abertas e algumas das pétalas já começam a cair.
FL - 3	Floração final	A maior parte das flores está sem pétalas ou com pétalas secas.
FR - 1	Início da frutificação	Estão visíveis os primeiros frutos.
FR - 2	Início da maturação dos frutos	Os primeiros frutos imaturos estão a ficar avermelhados.

FR - 3	Maturação dos 1os frutos	A planta está coberta de frutos imaturos e os primeiros frutos exibem a cor negro-lustrosa – maduros.
FR - 4	Maturação completa dos frutos	Mais de metade dos frutos estão maduros e já começam a cair.

Prunus lusitanica L.

(Loureiro-de-Portugal)

Código	Fenofase	Descrição
FL - 1	Início da floração	A planta está coberta de botões de flores e as primeiras flores estão abertas.
FL - 2	Floração intermédia	Metade da planta, ou mais, está coberta de flores abertas e algumas das pétalas já começam a cair.
FL - 3	Floração final	A maior parte das flores está sem pétalas ou com pétalas secas.
FR - 1	Início da frutificação	Estão visíveis os primeiros frutos.
FR - 2	Início da maturação dos frutos	Os primeiros frutos imaturos estão a ficar avermelhados.
FR - 3	Maturação dos 1os frutos	A planta está coberta de frutos imaturos e os primeiros frutos exibem a cor preta – maduros.
FR - 4	Maturação completa dos frutos	Mais de metade dos frutos estão maduros e já começam a cair.

Prunus persica (L.) Batsch

(Pessegueiro)

Código	Fenofase	Descrição
FO - 1	Desenrolar das 1as folhas	As primeiras folhas estão totalmente desenroladas.

FO - 2	Desenrolar das folhas	Metade das folhas da planta estão já totalmente desenroladas.
FL - 1	Início da floração	A planta está coberta de botões de flores e as primeiras flores estão abertas.
FL - 2	Floração intermédia	Metade da planta, ou mais, está coberta de flores abertas e algumas das pétalas já começam a cair.
FL - 3	Floração final	A maior parte das flores está sem pétalas ou com pétalas secas.
FR - 1	Início da frutificação	Estão visíveis os primeiros frutos (pêssegos).
FR - 2	Início da maturação dos frutos	Os primeiros pêssegos imaturos estão a ficar alaranjados.
FR - 3	Maturação dos 1os frutos	A planta está coberta de pêssegos imaturos e os primeiros pêssegos exibem a cor amarela ou alaranjada – maduros.
FR - 4	Maturação completa dos frutos	Mais de metade dos pêssegos estão maduros e já começam a cair.
SE - 1	Início da coloração de Outono	Algumas das folhas estão a perder a sua cor verde original.
SE - 2	Coloração de Outono	Metade das folhas, ou mais, perderam a cor original.
SE - 3	Queda outonal das folhas	A planta já perdeu metade das folhas, ou mais.
SE - 4	Fim da queda outonal das folhas	A planta já quase não tem folhas.

Prunus spinosa L.

(Abrunheiro)

Código	Fenofase	Descrição
FO - 1	Desenrolar das 1as folhas	As primeiras folhas estão totalmente desenroladas.
FO - 2	Desenrolar das folhas	Metade das folhas da planta estão já totalmente desenroladas.
FL - 1	Início da floração	A planta está coberta de botões de flores e as primeiras flores estão abertas.
FL - 2	Floração intermédia	Metade da planta, ou mais, está coberta de flores abertas e algumas das pétalas já começam a cair.
FL - 3	Floração final	A maior parte das flores está sem pétalas ou com pétalas secas.
FR - 1	Início da frutificação	Estão visíveis os primeiros frutos (abrunhos).
FR - 2	Início da maturação dos frutos	Os primeiros abrunhos imaturos estão a ficar azulados.
FR - 3	Maturação dos 1os frutos	A planta está coberta de abrunhos imaturos e os primeiros abrunhos exibem a cor azul-escura – maduros.
FR - 4	Maturação completa dos frutos	Mais de metade dos abrunhos estão maduros e já começam a cair.
SE - 1	Início da coloração de Outono	Algumas das folhas estão a perder a sua cor verde original.
SE - 2	Coloração de Outono	Metade das folhas, ou mais, perderam a cor original.
SE - 3	Queda outonal das folhas	A planta já perdeu metade das folhas, ou mais.
SE - 4	Fim da queda outonal das folhas	A planta já quase não tem folhas.

Quercus robur L.

(Carvalho-alvarinho)

Código	Fenofase	Descrição
FO - 1	Desenrolar das 1as folhas	As primeiras folhas estão totalmente desenroladas.

FO - 2	Desenrolar das folhas	Metade das folhas da planta estão já totalmente desenroladas.
FL - 2	Floração intermédia	Metade da planta, ou mais, está coberta de flores abertas e algumas das pétalas já começam a cair.
FR - 1	Início da frutificação	Estão visíveis os primeiros frutos (bolotas).
FR - 2	Início da maturação dos frutos	As primeiras bolotas imaturas estão a ficar acastanhadas.
FR - 3	Maturação dos 1os frutos	A planta está coberta de bolotas imaturas e as primeiras bolotas exibem a cor castanha – maduras.
FR - 4	Maturação completa dos frutos	Mais de metade das bolotas estão maduras e já começam a cair.
SE - 1	Início da coloração de Outono	Algumas das folhas estão a perder a sua cor verde original.
SE - 2	Coloração de Outono	Metade das folhas, ou mais, perderam a cor original.
SE - 3	Queda outonal das folhas	A planta já perdeu metade das folhas, ou mais.
SE - 4	Fim da queda outonal das folhas	A planta já quase não tem folhas.

Rhaphiolepis umbellata (Thunb.) Makino

(Rafiolépis)

Código	Fenofase	Descrição
FL - 1	Início da floração	A planta está coberta de botões de flores e as primeiras flores estão abertas.
FL - 2	Floração intermédia	Metade da planta, ou mais, está coberta de flores abertas e algumas das pétalas já começam a cair.

FL - 3	Floração final	A maior parte das flores está sem pétalas ou com pétalas secas.
FR - 1	Início da frutificação	Estão visíveis os primeiros frutos.
FR - 2	Início da maturação dos frutos	Os primeiros frutos imaturos estão a ficar azulados.
FR - 3	Maturação dos 1os frutos	A planta está coberta de frutos imaturos e os primeiros frutos exibem a cor azul-escura – maduros.
FR - 4	Maturação completa dos frutos	Mais de metade dos frutos estão maduros e já começam a cair.

Taxus baccata L.

(Teixo)

Código	Fenofase	Descrição
CO - 1	Aparecimento dos 1os cones femininos não maduros	Os primeiros cones femininos são visíveis.
CO - 2	Maturação dos 1os cones femininos	Os primeiros cones femininos estão rodeados por arilos carnudos e vermelhos – maduros.
CO - 3	Maturação completa dos cones femininos	Mais de metade dos arilos estão maduros e já começam a cair.

Tibouchina urvilleana (de Candolle) Cogniaux

(Tiboquina)

Código	Fenofase	Descrição
FL - 1	Início da floração	A planta está coberta de botões de flores e as primeiras flores estão abertas.

FL - 2	Floração intermédia	Metade da planta, ou mais, está coberta de flores abertas e algumas das pétalas já começam a cair.
FL - 3	Floração final	A maior parte das flores está sem pétalas ou com pétalas secas.
FR - 1	Início da frutificação	Estão visíveis alguns frutos imaturos.
FR - 2	Início da maturação dos frutos	Os frutos imaturos estão a ficar avermelhados.
FR - 3	Maturação dos 1os frutos	A planta está coberta de frutos imaturos e alguns frutos exibem a cor castanho-escura – maduros.
FR - 4	Maturação completa dos frutos	Mais de metade dos frutos estão maduros e já começam a cair.

Viburnum tinus L.

(Folhado)

Código	Fenofase	Descrição
FL - 1	Início da floração	A planta está coberta de botões de flores e as primeiras flores estão abertas.
FL - 2	Floração intermédia	Metade da planta, ou mais, está coberta de flores abertas e algumas das pétalas já começam a cair.
FL - 3	Floração final	A maior parte das flores está sem pétalas ou com pétalas secas.
FR - 1	Início da frutificação	Estão visíveis alguns frutos imaturos.
FR - 2	Início da maturação dos frutos	Os frutos imaturos estão a ficar avermelhados.
FR - 3	Maturação dos 1os frutos	A planta está coberta de frutos imaturos e alguns frutos exibem a cor azul-metálica – maduros.
FR - 4	Maturação completa dos frutos	Mais de metade dos frutos estão maduros e já começam a cair.

4. Guia de observação e registo

Pretende-se que o público monitorize as espécies selecionadas através do uso das fichas de monitorização e de uma câmara digital. Tanto os registos como a fotografias são essenciais para o estudo, por isso é necessário que o público obtenha os materiais necessários antes de proceder à monitorização. As informações necessárias para uma monitorização autónoma estão presentes em cada ficha de monitorização, por isso é importante que o público siga as instruções criadas.

4.1. Fichas de Monitorização

As fichas de monitorização são constituídas por diversas partes:

- **Texto introdutório** – para explicar o projeto e como utilizar as fichas;
- **Informação da espécie** - onde estão presentes o nome (científico e comum), número de exemplares a registar daquela espécie, números de identificação e localização de cada exemplar no parque;
- **Tabela de registos –** para o registo da data da observação (dia do mês e ano) e das fenofases (Presença (S), caso as fenofases estejam a ocorrer, ou Ausência (N), caso não estejam a ocorrer no momento de observação). Existe uma coluna com as fenofases que podem ser observadas para cada espécie e 3 a 5 colunas de exemplares, dependendo do número estabelecido para cada espécie. Cada fenofases a observar está apresentada em forma de questão, com a respetiva descrição e código criados para apoiar os observadores nos registos.
- **Fotografias das fenofases** – como apoio para identificação das fenofases nos exemplares, todas elas estarão representadas por uma fotografia. As fotos pertencem à espécie em estudo, no entanto, caso estas não existam, serão utilizadas fotos das mesmas fenofases, mas de outras espécies;

4.2. Passos para monitorização

Antes de iniciar

1. Para participar neste projeto, o visitante deverá deslocar-se preferencialmente a todos os grupos de árvores ou arbustos identificados no mapa, representativos de cada uma das espécies.
2. Deve observar cuidadosamente a planta (exemplar numerado e identificado no local) antes de iniciar o preenchimento da tabela.

3. O preenchimento da tabela deve ser feito para cada uma das plantas.
4. Para fazer esta **monitorização não é necessário recolher qualquer tipo de material (folhas, flores ou frutos)**. A recolha de folhas, flores ou frutos pode prejudicar o crescimento e desenvolvimento da planta e influenciar a monitorização das fenofases seguintes.
5. Cada uma das fenofases está ilustrada por uma fotografia, de forma a facilitar a sua identificação para o visitante.

Iniciar a monitorização

1. Registar a **data da observação** (dia/mês/ano).
2. Dirigir-se ao exemplar 1 de cada grupo.
3. Observar cuidadosamente toda a planta.
4. Registar a **presença** (escrevendo “**S**” de sim) ou **ausência** (escrevendo “**N**” de não) das **fenofases** listadas na tabela.
5. Repetir os passos anteriores para as restantes plantas da mesma espécie.

Finalizar a inventariação

O visitante deve visitar a plataforma de monitorização do Parque de Serralves: Biodiversidade e Ambiente, e registar as suas observações no módulo Serralves em Flora.

5. Conclusão

Para o projeto Serralves em Flora atingir o seu objetivo de estudar o efeito das alterações climáticas na flora de Serralves, é necessário que a monitorização feita pelo público seja continuada ao longo do tempo. Para tal acontecer é necessário encontrar formas de, continuamente, divulgar o projeto junto do público e motiva-lo a participar. Só com a continuidade do projeto e da recolha de dados é possível realizar um estudo contínuo e preciso do efeito das alterações climáticas ao nível da flora do Parque de Serralves.

Appendix X – Species selection table for “Serralves BioBlitz”

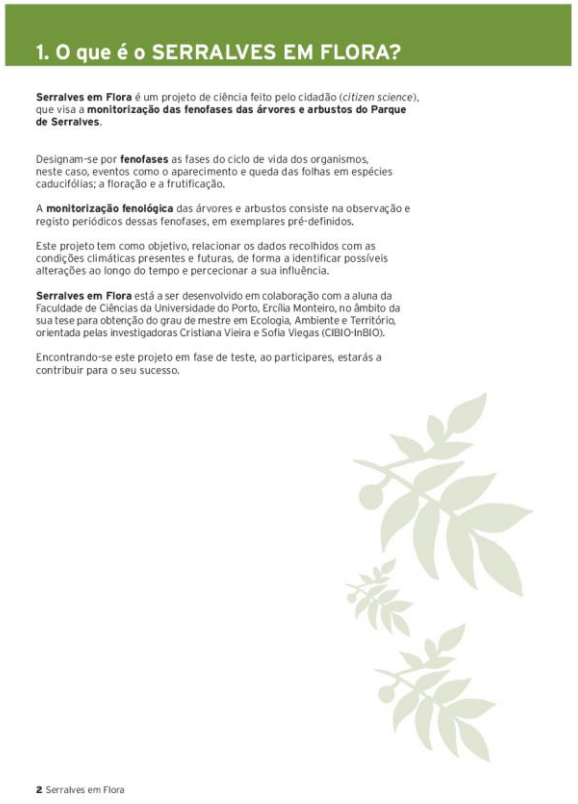
Nome e nº	Tipo de ficha	Floração	Maturação do fruto	Local no parque	Presença na chave de identificação ilustrada	Notas
Amelanchier ovalis Medik. (4)	T1	Março - Junho	Setembro	Clareira dos teixos	N	Algumas folhas a nascer
Arbutus unedo L. (3)	T3	Outubro - Fevereiro	Outubro	Bosque das faias	N	Presença de botões de flores, algumas flores e alguns frutos imaturos
Buxus sempervirens L. (4)	T3	Janeiro - Maio	Setembro	Lago	S	Flores secas e presença dos frutos
Citrus deliciosa Tenor (5)	T3	Abril - Maio	Setembro	Jardim das aromáticas	N	Alguns botões de flores e frutos maduros
Citrus limon (L.) Burm. fil. (5)	T3	Abril - Maio	Setembro	Jardim das aromáticas	N	Alguns frutos maduros
Citrus sinensis (L.) Osbeck (5)	T3	Abril - Maio	Setembro	Jardim das aromáticas	N	Alguns botões de flores e frutos maduros
Corylus avellana L. (5)	T2	Janeiro - Março	Setembro	Clareira das azinheiras	N	Não seria visível nada no bioblitz
Crataegus monogyna Jacq. (5)	T1	Março - Maio	Agosto	Clareira das azinheiras	N	Possível de observar as flores ou botões das flores no bioblitz
Cydonia oblonga L. (5)	T1	Março - Maio	Setembro	Horta pedagógica	N	Já com folhas e com a floração iniciada
Gardenia jasminoides J. Ellis (5)	T3	Maio - Setembro	Novembro	Jardim das camélias	N	Botões de flores
Ginkgo biloba L. (5)	T1	Março - Abril	Setembro	Assento agrícola do Mata-Sete	S	Dioica; a nascer as primeiras folhas
Ilex aquifolium L. (5)	T3	Abril - Julho	Outubro	Bosque das faias	S	Dioica, presença de bagas e alguns botões de flores a desenvolver
Laurus nobilis L. (3)	T4	Fevereiro - Maio	Setembro	Clareira das bétulas	S	Dioica; fase FL; já não vai ser visível no bioblitz
Prunus laurocerasus L. (4)	T3	Abril - Maio	Setembro	Parterre central	S	Final de floração
Prunus lusitanica L. (3)	T3	Maio - Julho	Setembro	Pátio do ulmeiro	N	Presença de algumas flores a desenvolver-se
Prunus persica (L.) Batsch (5)	T1	Março - Abril	Agosto	Horta pedagógica	N	Exemplares já com folhas e outros ainda com flores

N – não (no)
S – sim (yes)

Prunus spinosa L. (3)	T1	Março - Abril	Julho	Clareira dos teixos	N	Já com folhas e ainda algumas flores a cair
Quercus robur L. (3)	T1	Abril - Maio	Setembro	Clareira dos teixos	S	Já com algumas flores
Rhaphiolepis umbellata (Thunb.) Makino (3)	T3	Março - Maio	Setembro	Bosque do lago	S	Presença de botões de flores e algumas flores abertas
Taxus baccata L. (3)	T4	Março - Abril	Setembro	Lugar da oliveira; Roseiral	S	Dioica; fase CO; não se sabe se é masculino ou feminino ainda
Tibouchina urvilleana (de Candolle) Cogniaux (4)	T5	Julho - Setembro	Novembro	Assento agrícola do Mata-Sete	N	Fases repetem-se mais vezes por ano; algumas flores, frutos imaturos, maduros e ainda a amadurecer
Viburnum tinus L. (3)	T5	Janeiro - Abril	Setembro	Bosque das faias	S	Fases repetem-se mais vezes por ano; algumas flores e frutos maduros

N – não (no)
S – sim (yes)

Appendix XI – “Serralves BioBlitz” monitoring sheets



1. O que é o SERRALVES EM FLORA?

Serralves em Flora é um projeto de ciência feito pelo cidadão (*citizen science*), que visa a **monitorização das fenofases das árvores e arbustos do Parque de Serralves**.

Designam-se por **fenofases** as fases do ciclo de vida dos organismos, neste caso, eventos como o aparecimento e queda das folhas em espécies caducifólias; a floração e a frutificação.

A **monitorização fenológica** das árvores e arbustos consiste na observação e registo periódicos dessas fenofases, em exemplares pré-definidos.

Este projeto tem como objetivo, relacionar os dados recolhidos com as condições climáticas presentes e futuras, de forma a identificar possíveis alterações ao longo do tempo e perceccionar a sua influência.

Serralves em Flora está a ser desenvolvido em colaboração com a aluna da Faculdade de Ciências da Universidade do Porto, Ercília Monteiro, no âmbito da sua tese para obtenção do grau de mestre em Ecologia, Ambiente e Território, orientada pelas investigadoras Cristiana Vieira e Sofia Viegas (CIBIO-InBIO).

Encontrando-se este projeto em fase de teste, ao participares, estarás a contribuir para o seu sucesso.

2 Serralves em Flora

2. Protocolo de amostragem

Como monitorizar

Antes de iniciares

1. Para participares neste projeto, deverás deslocar-te preferencialmente a todos os grupos de árvores ou arbustos identificados no mapa, representativos de cada uma das espécies.

2. Deves observar cuidadosamente a planta (exemplar numerado e identificado no local) antes de iniciares o preenchimento da tabela.

3. O preenchimento da tabela deve ser feito para cada uma das plantas.

4. Para fazeres esta monitorização **não é necessário recolher qualquer tipo de material (folhas, flores ou frutos)**. A recolha de folhas, flores ou frutos pode prejudicar o crescimento e desenvolvimento da planta e influenciar a monitorização das fenosases seguintes.

5. Cada uma das fenofases está ilustrada por uma fotografia, de forma a facilitar a sua identificação.

Iniciar a monitorização

1. Regista a **data da observação** (dia/mês/ano).

2. Dirige-te ao exemplar 1 de cada grupo.

3. Observa cuidadosamente toda a planta.

4. Regista a **presença** (escrevendo “**S**” de sim) ou **ausência** (escrevendo “**N**” de não) das **fenofases** listadas na tabela.

5. Repete os passos anteriores para as restantes plantas da mesma espécie.

Finalizar a inventariação

1. Dirige-te à Estação das Plantas do BioBlitz ou aos pontos de Acolhimento (Entradas Marechal Gomes da Costa e Rua de Bartolomeu Velho) e entrega as tabelas preenchidas.

A tua colaboração é essencial: só assim poderemos avaliar o sucesso deste teste ao **Projeto Serralves em Flora!**

Diverte-te e obrigado!

3. Pontos de amostragem

1. Azevinho (*Ilex aquifolium*)
2. Folhado (*Viburnum tinus*)
3. Carvalho-alvarinho (*Quercus robur*)

4. Fichas de registo

Ponto 1 (5 exemplares)

Nome Comum: Azevinho
Nome Científico: ***Ilex aquifolium***

Data: ___ / ____ / ____

FENOFASES	É VISÍVEL...	Registo de Presença/Ausência (S/N) 1	2	3	4	5
FL (Flores)	**1 ...o início da floração?** (As primeiras flores estão abertas?)					
	2 ...a floração intermédia? (Metade da planta, ou mais, está coberta de flores abertas e algumas das pétalas já começam a cair?)					
	3 ...a floração final? (A maior parte das flores está sem pétalas ou com pétalas secas?)					
FR (Frutos)	**1 ...o início da frutificação?** (Estão visíveis os primeiros frutos?)					
	2 ...o início de maturação dos frutos? (Os primeiros frutos imaturos estão a ficar avermelhados?)					
	3 ...a maturação dos 1ºˢ frutos? (Os primeiros frutos exibem a cor vermelho-vivo?)					
	4 ...a maturação completa dos frutos? (Mais de metade dos frutos estão maduros e já começam a cair?)					

Fenofases

FL1. Início da floração (macho)

FL1. Início da floração (fêmea)

FL2. Floração intermédia

FL3. Floração final

FR1. Início da frutificação

FR2. Início de maturação dos frutos

FR3. Maturação dos 1ºs frutos

FR4. Maturação completa dos frutos

Ponto 2 (5 exemplares)

Nome Comum: Folhado
Nome Científico: *Viburnum tinus*

Data: ___ / ____ / ____

FENOFASES	É VISÍVEL...	Registo de Presença/Ausência (S/N) 1	2	3	4	5
FL (Flores)	**1 ...o início da floração?** (Existem algumas flores abertas?)					
	2 ...a floração intermédia? (Metade da planta, ou mais, está coberta de flores abertas e algumas das pétalas já começam a cair?)					
	3 ...a floração final? (A maior parte das flores está sem pétalas ou com pétalas secas?)					
FR (Frutos)	**1 ...o início da frutificação?** (Estão visíveis alguns frutos imaturos?)					
	2 ...o início de maturação dos frutos? (Os frutos imaturos estão a ficar avermelhados?)					
	3 ...a maturação dos 1ºs frutos? (Existem alguns frutos que exibem a cor azul-metálica?)					
	4 ...a maturação completa dos frutos? (Mais de metade dos frutos estão maduros e já começam a cair?)					

Fenofases

FL1. Início da floração

FL2. Floração intermédia

FL3. Floração final

FR1. Início da frutificação

FR2. Início de maturação dos frutos

FR3. Maturação dos frutos

FR4. Maturação completa dos frutos

Ponto 3 (3 exemplares)

Nome Comum: Carvalho-alvarinho
Nome Científico: *Quercus robur*

Data: ___ / ____ / ____

FENOFASES	É VISÍVEL...	Registo de Presença/ Ausência (S/N) 1	2	3
FO (Folhas)	**1 ...o desenrolar das 1ªs folhas?** (As primeiras folhas estão totalmente desenroladas?			
	2 ...o desenrolar das folhas? (Metade das folhas da planta estão já totalmente desenroladas?)			
FL (Flores)	**2 ...a floração intermédia?** (Metade da planta, ou mais, está coberta de flores abertas e algumas das pétalas já começam a cair?)			
FR (Frutos)	**1 ...o início da frutificação?** (Estão visíveis os primeiros frutos (bolotas)?)			
	2 ...o início de maturação dos frutos? (As primeiras bolotas imaturas estão a ficar acastanhadas?)			
	3 ...a maturação dos 1ºs frutos? (As primeiras bolotas exibem a cor castanha, significando que estão maduras?)			
	4 ...a maturação completa dos frutos? (Mais de metade das bolotas estão maduras e já começam a cair?)			
SE (Senescência)	**1 ...o início da coloração de outono?** (Algumas das folhas estão a perder a sua cor verde original?)			
	2 ...a coloração de outono? (Metade das folhas, ou mais, perderam a cor original?)			
	3 ...a queda outonal das folhas? (A planta já perdeu metade das folhas, ou mais?)			
	4...o fim da queda outonal das folhas? (A planta já quase não tem folhas?)			

Fenofases

FO1. Desenrolar das 1as folhas

FO2. Desenrolar das folhas

FL2. Floração intermédia

FR1. Início da frutificação

FR2. Início da maturação dos frutos

FR3. Maturação dos 1os frutos

FR4. Maturação completa dos frutos

SE1. Início da coloração de outono

SE2. Coloração de outono

SE3. Queda outonal

SE4. Fim da queda outonal

FICHA TÉCNICA

Conceção
Ercília Monteiro, Sofia Viegas

Revisão científica
Paulo Alves, Sofia Viegas, Cristiana Vieira

Coordenação
João Almeida

Créditos Fotográficos

Azevinho (*Ilex aquifolium*)
Stephan Hense, via Wikimedia Commons (CC BY-SA 3.0): FR4 • Lísia Lopes: FL2 • Philmarin, via Wikimedia Commons (CC BY-SA 3.0): FL1 (fêmea) • © Túrelio, via Wikimedia-Commons (CC BY-SA 2.5): FR3 • Sofia Viegas: FL3, FR2 • Frank Vincentz, via Wikimedia Commons (CC BY-SA 3.0): FL1 (macho), FR1

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Daderot, via Wikimedia Commons (Public Domain): FR2 • 'Gwenllian'-flower", via Wikimedia Commons (CC BY-SA 3.0): FL1• Lísia Lopes: FR4 • Daniel Ventura, via Wikimedia Commons (GFDL): FL2 • Sofia Viegas: FL3, FR1 • Vojtěch Zavadil, via Wikimedia Commons (CC BY-SA 3.0): FR3

Carvalho-alvarinho (*Quercus robur*)
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Appendix XII – Data documentation table for the “Serralves BioBlitz” results

Ilex aquifolium

Exemplar 1							Exemplar 2							Exemplar 3					
ID	Código BBCH	Código novo	Ano	Dia (do mês)	Dia (do ano)		ID	Código BBCH	Código novo	Ano	Dia (do mês)	Dia (do ano)		ID	Código BBCH	Código novo	Ano	Dia (do mês)	Dia (do ano)
11968	67	FL-3	2015	23/abr	113		11969	67	FL-3	2015	23/abr	113		11970	67	FL-3	2015	23/abr	113
11968	69	FR-1	2015	23/abr	113		11969	69	FR-1	2015	23/abr	113		11970	69	FR-1	2015	23/abr	113
11968	60	FL-1	2015	24/abr	114		11969	60	FL-1	2015	24/abr	114		11970	60	FL-1	2015	24/abr	114
11968	60	FL-1	2015	24/abr	114		11969	81	FR-2	2015	24/abr	114		11970	67	Fl-3	2015	24/abr	114
11968	67	FL-3	2015	24/abr	114		11969	60	FL-1	2015	24/abr	114		11970	69	FR-1	2015	24/abr	114
11968	69	FR-1	2015	24/abr	114		11969	67	Fl-3	2015	24/abr	114		11970	60	FL-1	2015	24/abr	114
11968	60	FL-1	2015	24/abr	114		11969	69	FR-1	2015	24/abr	114		11970	67	FL-3	2015	24/abr	114
11968	67	FL-3	2015	24/abr	114		11969	60	FL-1	2015	24/abr	114		11970	69	FR-1	2015	24/abr	114
11968	69	FR-1	2015	24/abr	114		11969	67	FL-3	2015	24/abr	114		11970	60	FL-1	2015	24/abr	114
11968	60	FL-1	2015	24/abr	114		11969	69	FR-1	2015	24/abr	114		11970	67	FL-3	2015	24/abr	114
11968	67	Fl-3	2015	24/abr	114		11969	60	FL-1	2015	24/abr	114		11970	69	FR-1	2015	24/abr	114
11968	69	FR-1	2015	24/abr	114		11969	67	FL-3	2015	24/abr	114		11970	67	FL-3	2015	24/abr	114
11968	60	FL-1	2015	24/abr	114		11969	69	FR-1	2015	24/abr	114		11970	69	FR-1	2015	24/abr	114
11968	69	FR-1	2015	24/abr	114		11969	60	FL-1	2015	24/abr	114		11970	60	FR-1	2015	24/abr	114
11968	67	FL-3	2015	24/abr	114		11969	69	FR-1	2015	24/abr	114		11970	67	FL-3	2015	24/abr	114
11968	69	FR-1	2015	24/abr	114		11969	67	FL-3	2015	24/abr	114		11970	69	FR-1	2015	24/abr	114
11968	60	FL-1	2015	24/abr	114		11969	69	FR-1	2015	24/abr	114		11970	67	FL-3	2015	24/abr	114
11968	67	FL-3	2015	24/abr	114		11969	67	FL-3	2015	24/abr	114		11970	69	FR-1	2015	24/abr	114
11968	69	FR-1	2015	24/abr	114		11969	69	FR-1	2015	24/abr	114		11970	67	FL-3	2015	24/abr	114

11968	67	FL-3	2015	24/abr	114		11969	67	FL-3	2015	24/abr	114		11970	69	FR-1	2015	24/abr	114
11968	69	FR-1	2015	24/abr	114		11969	69	FR-1	2015	24/abr	114		11970	60	FL-1	2015	24/abr	114
11968	60	FL-1	2015	24/abr	114		11969	60	FL-1	2015	24/abr	114		11970	67	FL-3	2015	24/abr	114
11968	67	FL-3	2015	24/abr	114		11969	67	FL-3	2015	24/abr	114		11970	69	FR-1	2015	24/abr	114
11968	69	FR-1	2015	24/abr	114		11969	69	FR-1	2015	24/abr	114		11970	67	FL-3	2015	25/abr	115
11968	67	FL-3	2015	24/abr	114		11969	67	FL-3	2015	24/abr	114		11970	69	FR-1	2015	25/abr	115
11968	69	FR-1	2015	24/abr	114		11969	69	FR-1	2015	24/abr	114		11970	67	FL-3	2015	25/abr	115
11968	81	FR-2	2015	24/abr	114		11969	81	FR-2	2015	24/abr	114		11970	69	FR-1	2015	25/abr	115
11968	67	FL-3	2015	25/abr	115		11969	67	FL-3	2015	25/abr	115		11970	67	FL-3	2015	25/abr	115
11968	69	FR-1	2015	25/abr	115		11969	69	FR-1	2015	25/abr	115		11970	69	FR-1	2015	25/abr	115
11968	67	FL-3	2015	25/abr	115		11969	67	FL-3	2015	25/abr	115		11970	67	FL-3	2015	25/abr	115
11968	69	FR-1	2015	25/abr	115		11969	69	FR-1	2015	25/abr	115		11970	69	FR-1	2015	25/abr	115
11968	67	FL-3	2015	25/abr	115		11969	67	FL-3	2015	25/abr	115		11970	67	FL-3	2015	25/abr	115
11968	69	FR-1	2015	25/abr	115		11969	69	FR-1	2015	25/abr	115		11970	69	FR-1	2015	25/abr	115
11968	67	FL-3	2015	25/abr	115		11969	67	FL-3	2015	25/abr	115		11970	67	FL-3	2015	25/abr	115
11968	69	FR-1	2015	25/abr	115		11969	69	FR-1	2015	25/abr	115		11970	69	FR-1	2015	25/abr	115
11968	67	FL-3	2015	25/abr	115		11969	67	FL-3	2015	25/abr	115							
11968	69	FR-1	2015	25/abr	115		11969	69	FR-1	2015	25/abr	115							
11968	67	FL-3	2015	25/abr	115		11969	67	FL-3	2015	25/abr	115							
11968	69	FR-1	2015	25/abr	115		11969	69	FR-1	2015	25/abr	115							

Exemplar 4							**Exemplar 5**					
ID	Código BBCH	Código novo	Ano	Dia (do mês)	Dia (do ano)		ID	Código BBCH	Código novo	Ano	Dia (do mês)	Dia (do ano)
11981	67	FL-3	2015	23/abr	113		11982	67	FL-3	2015	23/abr	113
11981	69	FR-1	2015	23/abr	113		11982	69	FR-1	2015	23/abr	113
11981	81	FR-2	2015	23/abr	113		11982	81	FR-2	2015	23/abr	113
11981	86	FR-3	2015	23/abr	113		11982	86	FR-3	2015	23/abr	113
11981	67	FL-3	2015	24/abr	114		11982	67	FL-3	2015	24/abr	114
11981	69	FR-1	2015	24/abr	114		11982	69	FR-1	2015	24/abr	114
11981	81	FR-2	2015	24/abr	114		11982	81	FR-2	2015	24/abr	114
11981	60	FL-1	2015	24/abr	114		11982	86	FR-3	2015	24/abr	114
11981	67	FL-3	2015	24/abr	114		11982	60	FL-1	2015	24/abr	114
11981	69	FR-1	2015	24/abr	114		11982	67	Fl-3	2015	24/abr	114
11981	81	FR-2	2015	24/abr	114		11982	69	FR-1	2015	24/abr	114
11981	60	FL-1	2015	24/abr	114		11982	81	FR-2	2015	24/abr	114
11981	65	FL-2	2015	24/abr	114		11982	86	FR-3	2015	24/abr	114
11981	69	FR-1	2015	24/abr	114		11982	60	FL-1	2015	24/abr	114
11981	81	FR-2	2015	24/abr	114		11982	65	FL-2	2015	24/abr	114
11981	67	FL-3	2015	24/abr	114		11982	67	FL-3	2015	24/abr	114
11981	81	FR-2	2015	24/abr	114		11982	69	FR-1	2015	24/abr	114
11981	86	FR-3	2015	24/abr	114		11982	81	FR-2	2015	24/abr	114
11981	67	FL-3	2015	24/abr	114		11982	86	FR-3	2015	24/abr	114
11981	69	FR-1	2015	24/abr	114		11982	60	FL-1	2015	24/abr	114
11981	81	FR-2	2015	24/abr	114		11982	67	FL-3	2015	24/abr	114
11981	69	FR-1	2015	24/abr	114		11982	81	FR-2	2015	24/abr	114
11981	81	FR-2	2015	24/abr	114		11982	86	FR-3	2015	24/abr	114
11981	86	FR-3	2015	24/abr	114		11982	67	FL-3	2015	24/abr	114
11981	65	FL-2	2015	24/abr	114		11982	69	FR-1	2015	24/abr	114
11981	67	FL-3	2015	24/abr	114		11982	81	FR-2	2015	24/abr	114
11981	69	FR-1	2015	24/abr	114		11982	86	FR-3	2015	24/abr	114
11981	81	FR-2	2015	24/abr	114		11982	69	FR-1	2015	24/abr	114
11981	67	FL-3	2015	24/abr	114		11982	81	FR-2	2015	24/abr	114
11981	69	FR-1	2015	24/abr	114		11982	86	FR-3	2015	24/abr	114
11981	60	FL-1	2015	24/abr	114		11982	67	FL-3	2015	24/abr	114
11981	67	FL-3	2015	24/abr	114		11982	69	FR-1	2015	24/abr	114
11981	69	FR-1	2015	24/abr	114		11982	81	FR-2	2015	24/abr	114
11981	81	FR-2	2015	24/abr	114		11982	86	FR-3	2015	24/abr	114
11981	60	FL-1	2015	24/abr	114		11982	67	FL-3	2015	24/abr	114
11981	67	FL-3	2015	24/abr	114		11982	69	FR-1	2015	24/abr	114
11981	69	FR-1	2015	24/abr	114		11982	60	FL-1	2015	24/abr	114
11981	81	FR-2	2015	24/abr	114		11982	69	FR-1	2015	24/abr	114
11981	67	FL-3	2015	25/abr	115		11982	60	FL-1	2015	24/abr	114
11981	69	FR-1	2015	25/abr	115		11982	67	FL-3	2015	24/abr	114
11981	81	FR-2	2015	25/abr	115		11982	69	FR-1	2015	24/abr	114

11981	67	FL-3	2015	25/abr	115		11982	81	FR-2	2015	24/abr	114
11981	69	FR-1	2015	25/abr	115		11982	86	FR-3	2015	24/abr	114
11981	81	FR-2	2015	25/abr	115		11982	67	FL-3	2015	25/abr	115
11981	67	FL-3	2015	25/abr	115		11982	69	FR-1	2015	25/abr	115
11981	69	FR-1	2015	25/abr	115		11982	81	FR-2	2015	25/abr	115
11981	81	FR-2	2015	25/abr	115		11982	86	FR-3	2015	25/abr	115
11981	67	FL-3	2015	25/abr	115		11982	67	FL-3	2015	25/abr	115
11981	69	FR-1	2015	25/abr	115		11982	69	FR-1	2015	25/abr	115
11981	81	FR-2	2015	25/abr	115		11982	81	FR-2	2015	25/abr	115
11981	67	FL-3	2015	25/abr	115		11982	86	FR-3	2015	25/abr	115
11981	69	FR-1	2015	25/abr	115		11982	67	FL-3	2015	25/abr	115
11981	81	FR-2	2015	25/abr	115		11982	69	FR-1	2015	25/abr	115
11981	67	FL-3	2015	25/abr	115		11982	81	FR-2	2015	25/abr	115
11981	69	FR-1	2015	25/abr	115		11982	86	FR-3	2015	25/abr	115
11981	81	FR-2	2015	25/abr	115		11982	67	FL-3	2015	25/abr	115
							11982	69	FR-1	2015	25/abr	115
							11982	81	FR-2	2015	25/abr	115
							11982	86	FR-3	2015	25/abr	115
							11982	67	FL-3	2015	25/abr	115
							11982	69	FR-1	2015	25/abr	115
							11982	81	FR-2	2015	25/abr	115
							11982	86	FR-3	2015	25/abr	115
							11982	67	FL-3	2015	25/abr	115
							11982	69	FR-1	2015	25/abr	115
							11982	81	FR-2	2015	25/abr	115

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Exemplar 1							**Exemplar 2**							**Exemplar 3**					
ID	Código BBCH	Código novo	Ano	Dia (do mês)	Dia (do ano)		ID	Código BBCH	Código novo	Ano	Dia (do mês)	Dia (do ano)		ID	Código BBCH	Código novo	Ano	Dia (do mês)	Dia (do ano)
11933	89	FR-4	2015	23/abr	113		11935	89	FR-4	2015	23/abr	113		11936	81	FR-2	2015	23/abr	113
11933	89	FR-4	2015	24/abr	114		11935	81	FR-2	2015	24/abr	114		11936	89	FR-4	2015	23/abr	113
11933	89	FR-4	2015	24/abr	114		11935	89	FR-4	2015	24/abr	114		11936	81	FR-2	2015	24/abr	114
11933	89	FR-4	2015	24/abr	114		11935	81	FR-2	2015	24/abr	114		11936	89	FR-4	2015	24/abr	114
11933	69	FR-1	2015	24/abr	114		11935	89	FR-4	2015	24/abr	114		11936	81	FR-2	2015	24/abr	114
11933	89	FR-4	2015	24/abr	114		11935	81	FR-2	2015	24/abr	114		11936	89	FR-4	2015	24/abr	114
11933	86	FR-3	2015	24/abr	114		11935	89	FR-4	2015	24/abr	114		11936	81	FR-2	2015	24/abr	114
11933	81	FR-2	2015	25/abr	115		11935	81	FR-2	2015	24/abr	114		11936	89	FR-4	2015	24/abr	114
11933	86	FR-3	2015	25/abr	115		11935	86	FR-3	2015	24/abr	114		11936	69	FR-1	2015	24/abr	114
11933	86	FR-3	2015	25/abr	115		11935	89	FR-4	2015	24/abr	114		11936	81	FR-2	2015	24/abr	114
11933	89	FR-4	2015	25/abr	115		11935	81	FR-2	2015	24/abr	114		11936	86	FR-3	2015	24/abr	114
11933	81	FR-2	2015	25/abr	115		11935	86	FR-3	2015	24/abr	114		11936	89	FR-4	2015	24/abr	114
11933	86	FR-3	2015	25/abr	115		11935	81	FR-2	2015	25/abr	115		11936	69	FR-1	2015	24/abr	114
11933	89	FR-4	2015	25/abr	115		11935	86	FR-3	2015	25/abr	115		11936	81	FR-2	2015	24/abr	114
11933	81	FR-2	2015	25/abr	115		11935	86	FR-3	2015	25/abr	115		11936	86	FR-3	2015	24/abr	114
11933	89	FR-4	2015	25/abr	115		11935	89	FR-4	2015	25/abr	115		11936	69	FR-1	2015	25/abr	115
11933	86	FR-3	2015	25/abr	115		11935	81	FR-2	2015	25/abr	115		11936	81	FR-2	2015	25/abr	115
11933	89	FR-4	2015	25/abr	115		11935	89	FR-4	2015	25/abr	115		11936	86	FR-3	2015	25/abr	115
11933	69	FR-1	2015	25/abr	115		11935	69	FR-1	2015	25/abr	115		11936	89	FR-4	2015	25/abr	115
11933	81	FR-2	2015	25/abr	115		11935	81	FR-2	2015	25/abr	115		11936	86	FR-3	2015	25/abr	115
11933	86	FR-3	2015	25/abr	115		11935	89	FR-4	2015	25/abr	115		11936	89	FR-4	2015	25/abr	115
11933	89	FR-4	2015	25/abr	115		11935	86	FR-3	2015	25/abr	115		11936	81	FR-2	2015	25/abr	115

							11935	89	FR-4	2015	25/abr	115		11936	89	FR-4	2015	25/abr	115
							11935	69	FR-1	2015	25/abr	115		11936	69	FR-1	2015	25/abr	115
							11935	81	FR-2	2015	25/abr	115		11936	81	FR-2	2015	25/abr	115
							11935	86	FR-3	2015	25/abr	115		11936	89	FR-4	2015	25/abr	115
							11935	89	FR-4	2015	25/abr	115		11936	86	FR-3	2015	25/abr	115
														11936	89	FR-4	2015	25/abr	115
														11936	69	FR-1	2015	25/abr	115
														11936	81	FR-2	2015	25/abr	115
														11936	86	FR-3	2015	25/abr	115
														11936	89	FR-4	2015	25/abr	115

Exemplar 4							**Exemplar 5**					
ID	Código BBCH	Código novo	Ano	Dia (do mês)	Dia (do ano)		ID	Código BBCH	Código novo	Ano	Dia (do mês)	Dia (do ano)
11938	69	FR-1	2015	23/abr	113		11940	69	FR-1	2015	23/abr	113
11938	81	FR-2	2015	23/abr	113		11940	81	FR-2	2015	23/abr	113
11938	89	FR-4	2015	23/abr	113		11940	89	FR-4	2015	23/abr	113
11938	81	FR-2	2015	24/abr	114		11940	81	FR-2	2015	24/abr	114
11938	81	FR-2	2015	24/abr	114		11940	81	FR-2	2015	24/abr	114
11938	81	FR-2	2015	24/abr	114		11940	81	FR-2	2015	24/abr	114
11938	89	FR-4	2015	24/abr	114		11940	89	FR-4	2015	24/abr	114
11938	89	FR-4	2015	24/abr	114		11940	89	FR-4	2015	24/abr	114
11938	89	FR-4	2015	24/abr	114		11940	89	FR-4	2015	24/abr	114
11938	69	FR-1	2015	24/abr	114		11940	69	FR-1	2015	24/abr	114
11938	81	FR-2	2015	24/abr	114		11940	81	FR-2	2015	24/abr	114
11938	86	FR-3	2015	24/abr	114		11940	86	FR-3	2015	24/abr	114
11938	89	FR-4	2015	24/abr	114		11940	89	FR-4	2015	24/abr	114
11938	69	FR-1	2015	24/abr	114		11940	69	FR-1	2015	24/abr	114
11938	81	FR-2	2015	24/abr	114		11940	81	FR-2	2015	24/abr	114
11938	86	FR-3	2015	24/abr	114		11940	86	FR-3	2015	24/abr	114
11938	89	FR-4	2015	24/abr	114		11940	89	FR-4	2015	24/abr	114
11938	81	FR-2	2015	25/abr	115		11940	69	FR-1	2015	25/abr	115
11938	89	FR-4	2015	25/abr	115		11940	81	FR-2	2015	25/abr	115
11938	86	FR-3	2015	25/abr	115		11940	86	FR-3	2015	25/abr	115
11938	89	FR-4	2015	25/abr	115		11940	89	FR-4	2015	25/abr	115
11938	69	FR-1	2015	25/abr	115		11940	86	FR-3	2015	25/abr	115
11938	81	FR-2	2015	25/abr	115		11940	89	FR-4	2015	25/abr	115
11938	86	FR-3	2015	25/abr	115		11940	81	FR-2	2015	25/abr	115
11938	89	FR-4	2015	25/abr	115		11940	86	FR-3	2015	25/abr	115
11938	69	FR-1	2015	25/abr	115		11940	89	FR-4	2015	25/abr	115
11938	81	FR-2	2015	25/abr	115		11940	81	FR-2	2015	25/abr	115
11938	89	FR-4	2015	25/abr	115		11940	89	FR-4	2015	25/abr	115
11938	69	FR-1	2015	25/abr	115		11940	69	FR-1	2015	25/abr	115
11938	81	FR-2	2015	25/abr	115		11940	81	FR-2	2015	25/abr	115
11938	86	FR-3	2015	25/abr	115		11940	86	FR-3	2015	25/abr	115
11938	89	FR-4	2015	25/abr	115		11940	89	FR-4	2015	25/abr	115
11938	69	FR-1	2015	25/abr	115		11940	69	FR-1	2015	25/abr	115
11938	81	FR-2	2015	25/abr	115		11940	81	FR-2	2015	25/abr	115
11938	86	FR-3	2015	25/abr	115		11940	86	FR-3	2015	25/abr	115
11938	89	FR-4	2015	25/abr	115		11940	89	FR-4	2015	25/abr	115

Appendix XIII – Scientific paper of “Serralves em Flora” project to be submitted to BioScience journal

Monitoring Plant Phenology between Citizens and Science: “Serralves em Flora”, a Case Study from Portugal

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Abstract

Climate change has been altering the flora cycles all over the world. Detecting this change requires a large scale observation data. Thanks to the citizen science programs, it is possible for volunteers to collect the phenological data from different places, consuming less time and resources. In this article it is created and tested, a methodology to develop a citizen science program to monitor plant phenology called “Serralves em Flora”, for Serralves Park, a private historic garden for public use, located in Oporto, Portugal. Therefore, the methodology used for the creation of this project was based on other existing programs and aggregated in nine methodological steps that are crucial for the designing and development of a plant phenology monitoring program. It is expected that, with the help of volunteers in the data collection through time, the study of the effect of climate change on Serralves Park flora becomes possible and sustainable.

Key words: climate change, phenophases, citizen science, methodological steps, monitoring networks

Introduction

To develop a phenology monitoring program and, in this case one focused on plants, it’s necessary to know about three major themes: **phenology**, **plant phenology monitoring** and **citizen science**.

Phenology is a science that studies cyclic events of the life cycle of living beings, which are called phenophases (Bruns et al. 2003; Luo et al. 2007; Schwartz et al. 2012). The methods to study phenophases usually include registration of the dates when these occur. After collecting systematic data over the years, it becomes possible to study the phenology of that organism (Mazer et al. 2011; Koch et al.; Haggerty and Mazer 2008).

There are two types of phenology: animal phenology and plant phenology. Each type studies a different group of phenophases, for example, migration events for animals and flower events for plants (Denny et al. 2014; Haggerty and Mazer 2008; USA-NPN 2013).

The actual and scientific reason beyond the importance of phenology studies is the monitoring of climate change phenomena. With the variances in the climate that the world is suffering, the organisms are trying to adapt so that they can continue living. This adaptations result in changes of the phenophases, more precisely, changes on the dates when they occur. These date changes can damage the ecological balance existing in the ecosystem where the altered living being is present. To try to minimize the impact that climate change can cause, the study of phenology can be used to predict future scenarios of phenophase alteration, allowing us, humans, the chance to prevent, if possible, or to adapt to them (Bruns et al. 2003; Haggerty and Mazer et al. 2008; Koch et al.; Luo et al. 2007; Mazer et al. 2011; Primack and Miller-Rushing 2009; Schwartz et al. 2012).

The study of phenology, in this case plant phenology, is made by **monitoring** through time. The more data obtained over the years, the better the study results and the more visible becomes the phenophase change over time (Haggerty and Mazer 2008; Koch et al.; Mazer et al. 2011).

For plant phenology monitoring there are three methods.

Direct observation and annotation, which is the most used by phenological programs, requires an amount of work and dedication by the observer and the materials consists on an observation sheet, usually already created by the programs (Bruns et al. 2003; Denny et al. 2014; Haggerty and Mazer 2008; Koch et al.).

Digital repeat photography is a less used method, due to the expensive and complex equipment required. It uses a digital camera, located on a strategic point to photograph several times a day the species observed, and a sophisticated software to analyse the photographs (Crimmins MA and Crimmins TM 2008).

Satellite phenology observation is the most sophisticated method since it used satellites to cover large areas of vegetation. Despite the large data collection, using only a satellite to gather data can create complications once

the data starts to be analysed. Having such a big distance from the study area, there can be some interferences on the received information, since the vast density of vegetation might not allow a consisted and detailed observation on the local area (Zhang et al. 2004, 2012).

All the gathered data can be placed on databases for climate change scientific studies. To develop a global scale study, monitoring networks were created. Their purpose is to gather data from different regions of the country, and analyse the changes that the species from each region suffered (Bruns et al. 2003; Zhang et al. 2012). Up to this day, there are different monitoring networks located in different places of the globe (Bruns et al. 2003; Zhang et al. 2012): PlantWatch from Canada, NPN (National Phenology Network) from the United States of America, EPN (European Phenology Network) from Europe, PEN (Phenology Eyes Network) from Japan, Nature’s Calendar from the United Kingdom.

Obtaining phenological data from different regions of the globe can be a very long and expensive work, if the ones collecting the data are the scientists themselves (Cohn 2008; Mayer 2010). To solve this problem, phenological programs use volunteers, which consists most of the time in citizens without formation on this area, to collect the data so that the scientists can use that data for their studies. This partnership between citizens and scientists is called **citizen science** and it has been used over the years in all phenological programs (Brossard et al. 2005; Cohn 2008; Dickinson et al. 2010; Mayer 2010). Volunteers can collect data from any region that they select as a study area, allowing the programs to gather a large amount of data from different regions more quickly and inexpensively. It is a goal for citizen science to change the mind of the volunteers that participate on the data collection about the environment and the climate change that are causes by anthropogenic influence (Brossard et al. 2005; Cohn 2008; Dickinson et al. 2010; Mayer 2010)

With citizen science, each program possesses data from their country. To obtain data from the rest of the globe, these programs make partnerships with other countries programs, creating networks that allow the data from each other to be shared by them. This network allows scientists to study the global variation of phenology more efficiently (Bruns et al. 2003).

Citizen science monitoring programs about phenology may have differences among each other, since they are located in different regions, but there are **nine methodological steps** that all have in common (Denny et al. 2014; Dickinson et al. 2010; Haggerty and Mazer 2008).

The observation method used must be able to be reproduced in any study area that volunteers choose and the materials must be easy to obtain and carry, but must also be precise to record data (Denny et al. 2014; Dickinson et al. 2010; Haggerty and Mazer 2008).

The monitoring scale selection must allow the volunteer to select any type of study area that he sees fit for his study, whether they be home gardens or city parks (Denny et al. 2014; Haggerty and Mazer 2008; Koch et al.).

The phenophase selection must use a certain criteria created thinking about the volunteers and their ability to observe and identify phenophases (Bruns et al. 2003; Haggerty and Mazer 2008; USA-NPN 2013).

The names of the phenophases given on the observation sheets must be understandable by the volunteers, so that they don’t be confused when observing what is asked (Denny et al. 2014; Haggerty and Mazer 2008; USA-NPN 2013).

The species selection must use a certain criteria that can determine if a species is adequate, or not, to be monitored (Haggerty and Mazer 2008; Koch et al.; Mazer et al. 2011).

The monitoring sheets must be easy to understand, carry and accessible to every citizen that wishes to became a volunteer. They also need to be able to be used in any type of study area and for any type of selected species (Denny et al. 2014; Elzinga et al. 1998; Haggerty and Mazer 2008).

The observation frequency of the phenophases can differ depending on the species to observe and the season. The study area can also influence the frequency that the volunteers visits her, depending if it is close or far away (Denny et al. 2014; Haggerty and Mazer 2008; Koch et al.).

The website of the phenological programs should be easy to use and understand by the volunteers. They should possess the core information about the selected species and their phenophases, as well as the monitoring sheets that should be used on the monitoring (Mayer 2010; *http://budburst.org/home; www.naturescalendar.org.uk/*; *www.usanpn.org/node/35*).

The data obtained by the volunteers’ observations goes through three stages before it is ready to be available to the public. The first one is the data documentation, which consists on the storage of the observed data on a database by the volunteer. The data quality control follows this step, where technicians and professionals on the area analyse the data of the database to see if the data it is correct or not. Guides are also used to control the quality of the data, since they are given to the volunteers before the data collection with precise instructions on how to correctly collect the data. The process and publication of the data is the last process. The data that passed the quality check is treated so that the phonological changes over the years is seen and is published on the website so that it can be accessed by anyone interested (Bruns et al. 2003; Cohn 2008; Dickinson et al. 2010; Haggerty and Mazer 2008; Koch et al.; Mayer 2010;).

As mentioned before, the citizens that decide to become volunteers are usually people that are interested in participating and learning new information about ecology. To allow them to observe phenophases and collect data that can be useful, it is necessary to prepare them for the task (Haggerty and Mazer 2008; Koch et al.; Mazer et al. 2011; Mayer 2010). The preparation consists in training sessions with technicians and phenological guides for volunteers to use during the observations (Mayer 2010; *www.usanpn.org/node/35*). The websites also contribute, since it contains theory information about phenological monitoring and already observed species data that can help guiding volunteers

in what they are expected to see (Haggerty and Mazer 2008; Mazer et al. 2011; Mayer 2010).

The world’s flora distribution and phenology is changing rapidly and with volunteer’s contribution, conservation assessments are possible (Luo et al. 2007; Primack et al. 2009; Tamis et al. 2005). Over the years, the number of citizen science programs has widely expanded. Nowadays, there are programs that allow schools to participate on plant monitoring, so that the students may have an early contact with nature and change their way of perceiving it (Haggerty and Mazer 2008; *www.usanpn.org/node/35*).

This work pretends to create a specific citizen science program (“Serralves em Flora”) on Serralves Park to analyse, over the years, the impact created by climate change on the park’s flora phenophases.

Methodological design for “Serralves em Flora”

Serralves Park, located in Oporto city (Portugal) is geographically placed on the transition climate zone between Atlantic and Mediterranean (Marques et al. 2014). This transitional climate allows a wider diversity of flora on the parks and gardens located in this city, more precisely, the co-existence of plants from different Atlantic and Mediterranean climates in the same area (Elzinga et al 1998; Ribeiro 1993).

With 18 hectares, Serralves Park is considered a fundamental ecological structure for Oporto city, revelling itself as an alive, dynamic and complex system. It is structured in three parts (a Museum (“Museu de Arte Contemporânea”), a House (“Casa de Serralves”) and a Garden (“Jardim de Serralves”) (Almeida et al. 2014; Nogueira et al. 2013a, 2013b) composed by three zones: the upper zone, the transition zone and the lower zone (Almeida et al. 2014; Mateus 2002; Nogueira et al. 2013b).

Serralves Park contains 8.000 exemplars of woody plants: trees and shrubs, natives and exotics. There are some native to Portugal rare species in the park, such as the yew and, some representing national flora, like the holly and cork oak. The exotic vegetation includes some emblematic trees, like the giant sequoia, and centennial plants, such as Japanese camellias. The flora is very important for the parks character, turning its landscape into a unique and sustainable place. For the fauna, Serralves Park contains a vast diversity of vertebrate and invertebrate animals. 98% of animal species are invertebrates and the remaining 2% are composed by 50 species of birds, 4 species of mammals, which are located on the Fields and represent endangered species of farms animals, 4 species of amphibians and 2 species of reptiles (Nogueira et al. 2013a).

All trees and shrubs present in the park are identified and georeferenced on a platform, which is used for divulgation and management of the botanical heritage of the park. Taking advantage of this platform, and promoting the dissemination of this plant heritage, the development of a flora monitoring project is a great asset, and complements the fauna monitoring project already implemented by Serralves Foundation.

The chronological steps taken for this project development were five, and each one of them possessed the same importance.

The **program research and contact** allowed to obtain information about the existing phenological programs through search of their websites, works and email exchange. After this research was made, we established a partnership between Serralves Park and the programs found.

The **nine methodological steps** for the creation of the citizen science monitoring program “Serralves em Flora” were adapted for this study area, as presented on Table 8.

Table 8 - Adaptation of the nine methodological steps for “Serralves em Flora" project.

1	Observation method	Select a simple observation method for visitors to apply.
2	Monitoring Scale Selection	Selection of Serralves Park area as the study scale.
3	Phenophase selection	Selection of phenophases based on the meta-analysis of the options used by other programs.
4	Names of the Phenophases	Convert scientific phenophase names to user friendly designations.
5	Species selection	Create a set of selection criteria to apply to Serralves plant species.
6	Monitoring sheets	Develop monitoring sheets simple to use and follow by the volunteers. Test the monitoring sheets with the public.
7	Observation Frequency	Determine how volunteers are allowed to observe when they come to visit the park.
8	Website	Create a web platform with the species information and training and monitoring sheets, using the existing fauna platform as a model.
9	Data	Collection and Documentation – register the dates when a phenophase is occurring during observation. Deposit the collected data on the database of the project.
		Quality control – create several tools to control the quality of the data that is gathered by the volunteers.
		Process and Publication – treat the final data with the statistical analysis methods found during research and present the results in graphics and tables.

The **test phases** were performed to test the created monitoring sheets on different stages of development and with different public, to help correct the underlying errors. Two different test phases took place: (1) test phase 1: made by the “Serralves em Flora” project’s team to test the monitoring sheets presentation and registration method; (2) test phase 2: conducted on the 24th and 25th of April of 2015 during “Serralves BioBlitz”, a public event that Serralves Park developed for flora and fauna inventory. Public adhesion and the phenophase definitions were tested, as well as the design of the monitoring sheets.

Pilot selection of species to test was made using the following criteria: **1) type of monitoring sheet**, which were given to the species based on the number of phases to observe and how many times a year this phase occurred (five types created); **2) flowering season**, which corresponds to the time of the

year that the species starts and ends the flowering phase; **3) fruit ripening**, which corresponds to the time of the year that the fruits of the species are ripe; **4) location in the park**, which corresponds the where each species is located on the Serralves Park; **5) presence in the identification key guide**, which was another activity of the “Serralves BioBlitz” program and the connection between this identification activity and “Serralves em Flora” monitoring project, allowed a shared pool of species in both activities.

The **analysis of the results obtained** from different phases of the work (surveys, registered data and test phases). This result analysis was used to determine errors and incorrect procedures that the volunteers can make during observation. These errors can lead to incorrect data, so detection and treatment are required.

The **adjustments and restatements** of the project were made to correct the work sessions that presented problems during the analysis of the results obtained.

Results

In the beginning of this work, we suggested that Serralves Park contacted the different programs found during research (*http://budburst.org/home; www.naturescalendar.org.uk/*; *www.naturewatch.ca/plantwatch/; www.obs-saisons.fr/; www.pep725.eu/index.php; www.usanpn.org/node/35*) for a possible partnership. Two programs responded to the request, USA-NPN Nature’s Notebook (*www.usanpn.org/node/35*) and PEP725 (Pan European Phenology Project) (*www.pep725.eu/index.php*), and a partnership was made.

“Serralves em Flora” is a citizen science phenological monitoring project that has been created for Serralves Park. This project’s objectives consist in monitoring certain plant species that are present in the park and assessing how the climate change could eventually affect their phenophases.

The **observation method** selected was the direct observation and registration method with photography support. It is the most simple and accessible one for the visitors of the park to use. The reason consists on the fact that sophisticated monitoring materials tend to be difficult to get and, in the case of people with no training nor formation in the area, difficult to use (Denny et al. 2014; Primack and Miller-Rushing 2009).

Serralves Park is private historic garden for public use located in the Oporto city, so the **scale** of this monitoring project is a local one.

The **selected phenophases** are a total of sixteen phases. Not every phase is going to be observed in every selected species, since some of them only appear on some types of species, for example the leaf fall only appears on deciduous species. For each phenophase it was adapted a definition, based on the already existing ones from the BBCH (“Biologische Bundesanstalt,

Bundessortenamt und Chemische Industrie”) list (Meier 2001), which is a list used to identify the phenological development stages of a plant, and the definitions from the PEP725, which Serralves Park developed a partnership with on the beginning of the project development. The phenophases and their definitions can be seen on Table 9.

Table 9- Selected phenophases and definitions

Phenophases	**Definitions**
First leaf unfolding	When the first leaves of the tree/shrub are fully opened
Leaf unfolding	When about half of the tree/shrub leaves are fully opened
First flowers open	When the first flowers of the tree/shrub are fully bloomed
Full flowering	When about half, or more, of the tree/shrub contains fully bloomed flowers. Some of the petals from the first bloomed flowers may already started to fall off
Flowering finishing	When most of the tree/shrub flower petals have fallen or got dry
End of flowering	When the first fruit sets became visible
Beginning of ripening	When the first fruits start to change its original colour to his mature colour
First ripe fruits	When the first fruits with the colour and the appearance of a mature fruit appear
Fully ripe fruits	When more than half of the fruits of the tree/shrub are fully mature. They start to fall naturally
Leaves beginning to discolour	When some of the leaves start to lose their original colour
Autumnal colouring of leaves	When half, or more, of the leaves of the tree/shrub lose their original colour, including the ones that have already fallen
Autumnal leaf fall	When half of the leaves of the tree/shrub have fallen
End of autumnal leaf fall	When almost all the leaves (95%) of the tree/shrub have fallen
First seed cones	When the first female cones are visible on the tree
First ripe seed cones	When the first female cones became covered by a red and fleshy aril (pseudo-fruit)
Full ripe seed cones	When more than half of the tree is covered with mature arils. Beginning of the natural fall of the seeds and the arils

The scientific **names of the phenophases** where adapted to more explicit ones, as well as the BBCH code that each phenophase had. The phenophases without BBCH code possess a N/A (not available) on the column instead of a number. The adaptations allow the visitors without specific knowledge about these subjects to understand what they’re asked to register. The adaptations are presented on Table 10 and are in Portuguese, once the program takes place in Portuguese soil.

Table 10 - Correspondence of the former phenophases codes and names to the new ones. (BBCH code – worldwide code number for the phenological development stages of plants)

BBCH Code	**Scientific name**	**New code**	**“Serralves em Flora” name**
11	First leaf unfolding	FO - 1	“Desenrolar das 1as folhas”
13	Leaf unfolding	FO - 2	“Desenrolar das folhas”
60	First flowers open	FL - 1	“Início da floração”
65	Full flowering	FL - 2	“Floração intermedia”
67	Flowering finishing	FL - 3	“Floração final”
69	End of flowering	FR - 1	“Início da frutificação”
81	Beginning of ripening	FR - 2	“Início de maturação dos frutos”

86	First ripe fruits	FR - 3	“Maturação dos 1os frutos”
89	Fully ripe fruits	FR - 4	“Maturação completa dos frutos”
92	Leaves beginning to discolour	SE - 1	“Início da coloração de Outono”
94	Autumnal colouring of leaves	SE - 2	“Coloração de Outono”
95	Autumnal leaf fall	SE - 3	“Queda outonal”
97	End of autumnal leaf fall	SE - 4	“Fim da queda outonal”
N/A	First seed cones	CO - 1	“Aparecimento dos 1os cones femininos não maduros”
N/A	First ripe seed cones	CO - 2	“Maturação dos 1os cones femininos”
N/A	Full ripe seed cones	CO - 3	“Maturação completa dos cones femininos”

The new code created contains key letters that represent the different parts and events of the plant: FO – folhas (leaves); FL – flores (flowers); FR – frutos (fruits); SE – senescência (senescence); CO - cones. The numbers that follow these key letters represent the number of the phenophase that belongs to that event. This new code structure will simplify the process of the data registration on the database since the registration codes for the phenophases are the same as the ones on the monitoring sheets. No BBCH code was found for the seed cones phases so, for these 3 phases, the BBCH code space is in blank (N/A) and the data registration of these 3 phases will only use the new code. Using the same type of presentation used by the USA-NPN program (*www.usanpn.org/node/35*), each phenophase name and definition is presented in the form of a question in the registration table.

The **selection of species** was made using the criteria found on research (Bruns et al. 2003; Denny et al. 2014; Haggerty and Mazer 2008) and additional criteria required for the adaptation to the study area. The eight criteria groups are divided in five crucial criteria and two others that can support the decision of the species selection.

The five crucial criteria are: **1) the life form**, which determines if the plant species is a tree, shrub or herbaceous; **2) the origins**, which determines if the specie is autochthonous from Portugal, or not; **3) the present structures and visibility**, which determines the plant structures connected to the phenophases and if they are visible for an easy detection or not; **4) the number of exemplars**, which determines the number of exemplars with the same shape and conditions present on the park for each species; and **5) the individual’s proximity and access**, which determines from all existing individuals of each species present in the park, which ones should be selected, by their proximity to each other and easy public access.

The three additional criteria are the **biogeographic distribution**, which determines the natural climate of the plant species, the **invasive nature**, which classifies the species as an invasive species or not; and the **conservation status**, which determines if the species possess any conservation concern or not.

From the original 201 tree/shrub list of plant species that Serralves Park possesses, 22 species where selected as possible monitoring species (Table 11). Four of the selected species did not fulfil all of the crucial criteria mentioned

above, but they were selected since they are common species or seen as emblematic species in the country. These species were *Buxus sempervirens* (boxwood), *Laurus nobilis* (laurel), *Quercus robur* (English oak) and *Taxus baccata* (yew).

Table 11 - The 22 selected species to monitor.

Amelanchier ovalis Medik.	*Ilex aquifolium L.*
Arbutus unedo L.	*Laurus nobilis L.*
Buxus sempervirens L.	*Prunus laurocerasus L.*
Citrus deliciosa Tenor	*Prunus lusitanica L.*
Citrus limon (L.) Burm. fil.	*Prunus persica (L.) Batsch*
Citrus sinensis (L.) Osbeck	*Prunus spinosa L.*
Corylus avellana L.	*Quercus robur L.*
Crataegus monogyna Jacq.	*Rhaphiolepis umbellata (Thunb.) Makino*
Cydonia oblonga L.	*Taxus baccata L.*
Gardenia jasminoides J. Ellis	*Tibouchina urvilleana (de Candolle) Cogniaux.*
Ginkgo biloba L.	*Viburnum tinus L.*

The **monitoring sheets** were based on the existing sheets of other phenological programs (*http://budburst.org/home; www.naturescalendar.org.uk/*; *www.naturewatch.ca/plantwatch/; www.obs-saisons.fr/; www.pep725.eu/index.php; www.usanpn.org/node/35*), but were adapted for the species of Serralves Park. Afterwards, we performed some preliminary tests with the draft monitoring sheets, observation and registration tests, to check the suitability of the sheets (phase 1 of tests). The species used for the preliminary test were *Cydonia oblonga* (quince tree), *Prunus persica* (peach tree) and *Tibouchina urvilleana* (princess flower). During the visit to the park in April 2015, these three species were showing the occurrence of some phases, so it was decided to use them to test the monitoring sheets. This test allowed the detection of some problems that could lead to misinterpretation and confusion, resulting in errors on the phase registration. After this, several modifications were made on the monitoring sheet to solve the problems encountered. The final version of the monitoring sheet of “Serralves em Flora” presents the following information:

1) Introduction – a small text that explains the purpose of this work to the volunteers, guidelines for proper monitoring practice;
2) Name of the specie - both common and scientific name are required;
3) Location where the data was collected – Serralves Park;
4) Serial number of the species exemplars – the numbers that are given to each plant present in the park. These numbers are connected to the database and can be used to locate a plant on the website map;
5) Species locations on a map of Serralves Park – a portion of the map of Serralves Park that shows the location of the species exemplars on the park;

6) Registration table – a table that contains the exemplars in each columns and the phenophases to identify in each line. Each phenophase contains the corresponding colour, code and definition created. The table and the phenophase definition are written in the form of a question, captivating more the volunteers and lowering the difficulty of the phenophase identification. The volunteers should register the day of the month and the year of the observation, followed by the presence/absence of the phenophases presented on the table for each exemplar of each species. The presence/absence should be written with S (“sim”, meaning yes) or N (“não”, meaning no) respectively;
7) Image guideline – located after the record sheet, it contains photographs to help to recognize the phenophases pointed at the record table. The images are photos already taken to the same phenophases that the volunteer is monitoring, allowing him to know how they looks like.

For the **observation frequency** there isn’t an exact schedule to follow. Serralves is a private park, which difficult the daily visit for the visitors, and each person has their own daily schedule to follow, leading to less time to do monitor. The visitor should monitor once a week or less (Haggerty and Mazer 2008; Koch et al.; Mazer et al. 2011), but it is still the visitor that decides when he has the time to spare to monitor.

Serralves Park already possesses a citizen science platform for their fauna monitoring (“Biodiversidade e Ambiente”), so the **website** for this project already has a base. The structure of the “Serralves em Flora” new module would be similar to the existing programs, containing a simple introduction to several concepts (phenology, citizen science, monitoring…), a list of the species, with the corresponding information (descriptions, phases, event dates…), photos and monitoring sheets of the species and a map of Serralves park with the location of every individual of every species existing in the park. This map will allow the visitors to choose the wanted species and individual, see its location in the park and access the information sheet of the species. The monitoring guide to help volunteers in the field is included in the monitoring sheets, with 2 introductory chapters. The first chapter explains the project, while the second explains the necessary steps to follow when monitoring a plant species. Finally, the website should contain the “Serralves em Flora” database, where the volunteers can register the observed data, and a control system for the data and photos submitted, so that only the data that is accurate can be used for studies.

The **data documentation** (metadata) should be stored on the website on the database of “Serralves em Flora”. To data storage each document has 22 tabs, one for each of the 22 species. Each tab possesses several tables, each one corresponding to each individual that the species comprises. Each table possesses the exemplar number of the species individual, the identification number (ID) of the individual that is the number that Serralves used to register it on the database, the BBCH code and new code of the phenophases, the year, day of the month and the day of the year when phenophases were occurring during observation (Table 12).

Table 12 - Example of the data documentation table. (ID – identification number; BBCH code – worldwide code number for the phenological development stages of plants)

Exemplar 1					
ID	BBCH code	New code	Year	Day (of the month)	Day (of the year)
2439	60	FO - 1	2015	21/03	80

It is expected that volunteers register their own collected data on the website in the future but, until the website database is finished, the data will be registered by the staff of Serralves with the observations recorded and delivered by the volunteers.

The **data quality control** would be made by training sessions, which would occur during events on the park and would be carried out by the technicians of "Serralves em Flora" project, and the analysis of photos taken during observations, which would be compared with the data deposited on the database by the same volunteer. Additional material that can help the volunteers to register the data correctly would be present on the website.

A phenological monitoring guide was created for the staff of Serralves Park with all the information about the project, its principles and fundamentals, and best practice procedures. This will ensure the continuity of this project over the time, even if the staff of the park changes.

To **process** the obtained data over time, in order to determine the phenophase variations, it is necessary a statistical analysis (Dennis 2004; Qian and Shen 2007).

In the first year, an ANOVA test will be used for statistical analysis and the final data is placed on a bivariate graphic (time vs. date of phenophase) that will show the changes that occur over the years on the dates of the phenophases for each studied plant. For each plant species' phenophase, a different graphic should be created. This way it will be possible to infer the effect of climate change on each stage of the plants cycle and contribute with data to other European platforms. Serralves will contribute to the PEP725 (*www.pep725.eu/index.php*) and USA-NPN (*www.usanpn.org/node/35*) platforms, since partnerships were established with them (Luo et al. 2007; Schwartz et al. 2012; Shustack et al. 2009).

For the first 2 years of collected data, a t-test should be use to compare the means of each species in these 2 years for each phenophase. The species means would be calculated using specific statistical software. The confidence level will be set to 95%.

For 3 or more years of collected data, an ANOVA test is required. The species' observed phenophase data averages would be calculated using specific statistical software. The confidence level will be set to 95%.

The **data publication** will be made in the website, on the "Serralves em Flora" module. The results will be presented through tables and graphics with

open access to the public (Luo et al 2007; Shustack et al 2009; Ungersbõck et al. 2013).

On April 24th and 25th the “Serralves BioBlitz” event for the public was used as an opportunity to test the monitoring sheets for 3 of the 22 species: *Ilex aquifolium* (holly tree), *Quercus robur* (English oak) and *Viburnum tinus* (laurustinus) and the layout of their monitoring sheets were made in the format of a small notebook, so that people could carry it around and use it more easily. A total of twenty-one notebooks were used by the visitors and the number of observations per notebook for the *Ilex aquifolium*, *Quercus robur* and *Viburnum tinus* were 17, 2 and 11 respectively.

The major difficulties that the visitors had resided on the **First flowers open** and the **First ripe fruits** phenophases. Based on these evidences some modifications were made on the description of these phenophases in the monitoring sheets, to avoid misunderstandings on future observations. Another problem pointed by some visitors was the existing **number of exemplars** per species to observe. For some visitors, five exemplars to observe proved to be a tiring activity, leading to their lack of interest on plant monitoring over some time.

The quality control of this test phase was made by creating a control monitoring sheet for the three species. On the day before the event (the 23th of April), each species was monitored and these results were compared to the ones obtained by the visitors. Also, the responsible team for this activity on “Serralves BioBlitz” followed the visitors to the observations sites, providing an explanation of the activity, and demonstrating the procedure.

Discussion

“Serralves em Flora” is a citizen science phenological project specifically developed for Serralves Park and uses the existing information that was found during research about this topic and the meta-analysis of the existing monitoring programs previously discussed. Although we based some of the decisions on options of other programs, some difficulties were encountered resulting from the lack of information on the programs. Despite these difficulties, “Serralves em Flora” project was developed and tested in several moments, namely during a 2-day event in 2015 involving the public that usually visits the Serralves Park.

In the starting phase of the project development two **partnerships** were established between Serralves Park and two phenological programs: PEP725 (*www.pep725.eu/index.php*) and the USA-NPN (*www.usanpn.org/node/35*). This partnerships shared information (Haggerty and Mazer 2008; Koch et al.; Mazer et al. 2011; Ungersbõck et al. 2013; USA-NPN 2013) that was used on the adaptation of the nine methodological steps for the “Serralves em Flora”

project and on the simplification of the data sharing between the programs database.

The **species selection** criteria developed for the “Serralves em Flora” allowed to select the more indicated species for volunteers to study among the 201 species existing in the park. Still, the selection of the four species that did not fulfil all the crucial criteria showed that it is still possible to study them if the definition and images of the phenophases are correctly explained and identified respectively. Also, the criteria created for this project can also be used in different study areas, since most of the information required for each species can be found on the internet, the exception is the number of exemplars with the same characteristics (age, growing rate, physical appearance…) on the same area.

The **“Serralves BioBlitz”** event allowed to test, with heterogeneous public (scholar and general public), the choices made for the “Serralves em Flora” project, more precisely the: **(1) observation method selected**, which proved to be adequate for the activity, since the visitors had access to the materials required (the monitoring notebooks) and understood quite easily the way to observe and to register the information, **(2) selected phenophases**, which were easily identified by the visitors, **(3) name and definition adaptation** of the phenophases, which only lead to confusion and incorrect identification of two phenophases (“first flowers open” and the “first ripe fruits”) that were corrected after the test, **(4) monitoring sheets**, which proved that the final design and information given allows volunteers to monitor plant species autonomously, and **(5) quality control tools**, which showed that the formation session given before the observation activity helped some volunteers to identify correctly the phenophases, including the two that leaded to confusion (“first flowers open” and the “first ripe fruits”), and that the control monitoring sheet could show the major problems that volunteers possess in the phenophase identification.

The **data storage** file actual design allows to store the data for the twenty-two species selected over the years, but whenever the database of the “Serralves em Flora” website is finished, the design will change so that volunteers store their data more easily. The volunteer would store their data using the registration table phenophase code and colour present on the monitoring sheets as a guide on the database. The monitoring sheets used on the “Serralves BioBlitz” did not possess colours associated with the phenophases codes, since the data results would be stored by the person in charge of the coordination of the activity and not by the volunteers, but if the volunteers understood the registration table division for each phase group (FO, FL, FR, SE, CO) then the use of colour would make the division easier to submit the data, matching the monitoring sheet colours with the ones on the website storage.

As mentioned before, some problems were encountered during this work. One of the problems was the **contact with the other phenological programs**. The partnerships were established with two of them

(*www.pep725.eu/index.php*; *www.usanpn.org/node/35*), but getting in touch with them or with the other programs was a challenge. Some programs never replied to the requests or questions that were sent and others took too long to reply. Sometimes, the answer was not helpful for our work.

Problems also occurred on the **phenophase selection** and **new denomination and definition**. All programs followed the BBCH list (Meier 2001), but each one selected the phenophases that they saw fit for each of their selected species and created a name and definition different from the other programs, so it was difficult to decide which phenophases to use and which name and definition to give. Also, since “Serralves em Flora” is a Portuguese project, the **language differences** created another problem on the new denomination and definition of the phenophases. It was necessary to translate the information, but in a way that the translation did not altered the true concept of the chosen phenophases.

Another difficulty resided on the **species selection** phase, more precisely on the exemplars to monitor for each species. Since the exemplars needed to be close to each other, so that they could all suffer the same ecological conditions (shade, temperature…) and have similar morphological characteristics (size, shape…), the accomplishment of these conditions implied a lot of search to find exemplars for each taxa. There were several rejections and visits to Serralves Park before selecting the final exemplars for the final twenty-two species.

The **monitoring sheets** design also presented several problems, as the type of information to use, how to present the information, how to register the data and how to make the sheet easy to understand and to be used by the volunteers. Several modifications were made, the majority was made in the registration table, since the information presented needed to be simple to understand and use, while being informative and correct. The monitoring sheet size also needed to be considered to allow volunteers to easily carry and use it, so the information distribution was rearranged several times to fulfil that requisite.

The programs presented information on the documentation, quality control and publication of their data, but for the **statistical analysis** some of the necessary information was lacking, which led to some difficulties for our work. The type of tests suitable to apply to this kind of data were already proposed, since they were mentioned in other programs, but information of the type of data to use and the way to input data were the main uncertainties, since the information regarding this topic on articles was not developed enough (some works only mentioned the test used and the results, others only showed the graphics and the remaining information was not mentioned at all) [Pimack et al. 2009; Shustack et al. 2009].

Conclusion

This work collected a vast amount of information about scientific phenology monitoring works and citizen science phenological programs and merged the most important contents of each area to originate the “Serralves em Flora” project. Although there were some difficulties in collecting and selecting some information, this project thrived and developed and was ultimately tested a monitoring program with the Serralves Park’s public.

There are still components of the project to finish (website and database) and to test (use of digital camera, use of the website and database by the volunteers), but, when everything is finished and tested, it is expected that “Serralves em Flora” is officially integrated in Serralves Park and that the visitors contribute to the data collection over time. This way, the climate change impact on the park’s flora can be studied and the results can be shared with the partner programs in Europe and USA.

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